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UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

INSTRUCTIONS FOR STUDYING FIRES

Edward G. Heilman, Forester
U. S. Forest Service
Marana Air Park
Marana, Arizona 85238

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USDA Forest Service
240 W Prospect Rd
Fort Collins CO 80526

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Reg 3

RECEIVED U.S.F.S.
AUG 4 1967
FIRE

8/9/67

FORM 6200-8 (1/64)
UNITED STATES GOVERNMENT

Memorandum

Department of Agriculture—Forest Service

Washington, D. C. 20250

TO : Director, SE Area; Director, NE Area; Director, Div. of Adm. Mgt.; All Regions

File No. 5100

FROM : R. F. Droege, Assoc. Deputy Chief National Forest System

Date: AUG 1 1967

SUBJECT: Fire Control

Your reference:

During late June the Forest Service entered into a project with the Office of Civil Defense to prepare Sample Fire Defense Plans and study large fires. Leadership for the project is centered in the Division of Fire Control with Jim Jay, Chief, Fire Defense Activities Branch, in charge. In addition to contributing to overall Civil Defense, the results of this work will benefit Forest Service peacetime fire control operations. The project is an outgrowth of the National Fire Coordination Study, and it will continue until June 30, 1969.

To be ready to study large fires that may occur, fire analysts need to be designated, trained and available to go to fires on short notice. The first training will be held at Washington, D. C., August 16.

Two of the trainees are from the Washington Office, Division of Fire Control. Through consultation with Regions 3, 8, Northeast Area and Southeast Area, additional trainees have been agreed upon. Men selected so far to receive the one day training are:

Ed Heilman, Region 3
Dick Woody, Region 8
Hugh E. Mobley, Jr., Southeast Area, S&PF
Douglas H. Baker, Northeast Area, S&PF
Robert J. Graves, Washington Office, Division of Fire Control
Hugh H. Fowler, Washington Office, Division of Fire Control

Instructors for the training will be:

James W. Jay, Washington Office, Division of Fire Control
Robert L. Bjornsen, Washington Office, Division of Fire Control
Frank Lewis, Washington Office, Division of Administrative Management

8-4-67

FIM

cc: Heilman
Comacho

Trainees should report to the Division of Fire Control, Room 701-C, 1620 No. Kent Street in Rosslyn, a part of Arlington, Virginia, near South end of Key Bridge, by 9:30 a.m., August 16.

The Francis Scott Key Hotel, 20th and F Streets, NW, is suggested as a place to stay. Trainees can either ask us or make their own reservations. DC Transit Bus No. 38 can be caught on Pennsylvania Avenue, West bound, crossing Key Bridge to Rosslyn Circle. From there it is a short walk to the meeting place.

Travel and per diem costs for the trainees will be paid by the Washington Office, Division of Fire Control. These costs should be charged to account number 802-311-312-01-46-02.

Richard Fahey

1700
Project 0083

SCHEDULE FOR TRAINING IN THE STUDY OF LARGE FIRES
August 16, 1967, 0930 Hrs.

Hour	Item	Leader
0930 Hrs.	A. Introductions	Jim
	B. Schedule for today Coffee and lunch as convenient	
	C. Purpose in studying large fires	
	Relate to Project 229	Jim
	Relate to Project 0083	Jim
	Relate to Fire Services	Jim
	Relate to FS responsibility to National Fire Defense	Roy Olson
	D. Objectives	Jim

Objectives of Fire Studies:

To relate findings on peacetime fires to possible nuclear fire situations. (See page 4 of "Instructions")

Objective of today's training:
To develop uniformity of analyses and reports aimed at meeting the needs of Project 0083.

It is not to train in the collecting, organizing, or synthesizing of information nor in report writing.

Your initiative, self-training, and study of the reference materials will enable you to study fires and meet the objectives.

Hour	Item	Ref. No.	Leader
1030 Hrs.	The 19 key areas:		
	Pre-planning and Prevention	13	Jim
	Mutual Aid	1	Jim
	Multi-organization Command	2	Bob
	Training Overhead and Others	14	Bob
	Tactics and Equipment	12	Frank
	Weather Factors	18	Frank
	Fuel	15	Jim
	Protecting Key Structures	6	Jim
	Control Objectives	11	Bob
	Estimating Needs	10	Bob
	Cost-benefit -- Values Sacrificed	7	Frank
	Evacuation	9	Frank
	Strategic Redeployment	8	Bob
	Logistics and Timing	16	Bob
	Resource Locators	3	Frank
	Communications	4	Frank
	Fatigue	17	Bob
	Problems that if solved ---	5	Bob
	Unforeseen	19	Jim
	Data Sheets, Appendix		Jim
1630 Hrs.	E. Procedural steps in making study		Jim
	Receive alert or request		
	Make travel reservations		
	Rendezvous with teammate		
	Contact local fire authorities		
	Collect information		
	Organize information		
	Synthesize information		
	Write report		

Hour	Item	Leader
	F. Preliminary Preparations GSA car or Hertz credit card TR book Know travel regulations Camera Self-training	Jim
	G. Preparation of Maps, Tables, and Visual Aids	Bill
	H. Foreseeable Problems Coordination thru local fire service Local travel Discussion	Jim
1115 Hrs.	ADJOURN	

Scheduled Attendees:

Ed Heilman, Region 3
Dick Woody, Region 8
John Chaffin, Region 9
Hugh E. Mobley, Jr., Southeast Area, S&PF
Douglas H. Baker, Northeast Area, S&PF
Robert J. Graves, Washington Office, Division of Fire Control
Hugh H. Fowler, Washington Office, Division of Fire Control

INSTRUCTIONS

FOR STUDYING FIRES

PROJECT 83

Prepared By	Date	
James W. Jay	July 17, 1964	Revised 8/1/67
Leslie L. Colvill	July 17, 1964	
W.R. Moore	July 24, 1964	Revised August 10, 1964

Reviewed By	Date	Approved By	Date

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I. SCOPE OF THE STUDY

The fire study is to be completed as a part of Project Order No. 83. Past and current fires will be selected for study using the criteria in Appendix A. During the study of each fire, data will be gathered, which can be used to achieve the objective of Project 83. Broadly stated, the objective of the fire studies is to provide a realistic base on which to build useable fire defense plans; to relate specific real peacetime problems to possible wartime fire situations.

A separate report will be developed on each fire studied. The lessons learned from each fire study will be used at appropriate times as Project 83 progresses. Copies of each fire study report will be submitted to the Office of Civil Defense.

II. OBJECTIVES OF THE FIRE STUDIES

The objectives of the fire study are:

1. To search out the factors important to better utilizing the capabilities of Federal, State, Local, and Private fire organizations in effective control of mass fires.

2. To identify those problems which relate to the effectiveness of fire suppression.

3. To identify strategies and tactics which could be adapted to protecting shelters.

4. To identify measures that can be taken in advance to lessen the likelihood of ignition from fire, lessen the severity of the fire, and to improve effectiveness of control.

5. To relate effectiveness of strategy, tactics, and logistics commonly used in suppressing large fires to the problem of suppressing fires where nuclear fallout is involved.

6. To identify additional factors that will add to the quality of Project Order No. 83.

III. CONDUCTING THE STUDY

Fires to be studied will be selected by the Project 83 Task Force. A cross section of past fires will be selected. Large fires which occur during the course of Project 83 will also be studied on site. The logistics of studying going fires will be different than studying past fires, but the objectives remain the same. Thus, these procedures apply to both types of fires. The fire analyst is expected to adapt his approach and logistics to the situation.

Having selected a fire for study, the Chief of Project 83 will assign the fire to a team of analysts for study. Two men will usually make up the team. In this way, the skills necessary to meet the study objectives will be available. The project Chief will assign one of the analysts as the study leader.

The team may work together or separately. For example, one member might be analyzing records in Washington while another is interviewing key people who participated in the suppression action.

The study leader is responsible to see that the study is carried out, that the objectives stated in Section II of this plan are met, and that three copies of a report in double spaced draft form are submitted to Project 83 within 15 days after the study is complete. See Appendix F for report outline.

Each fire analyst will receive training in fire study procedures. It is essential that each analyst understand the reasons behind the study and how his findings will be used in Project 83.

Logical steps for the team to follow when they receive a fire study assignment are:

1. Assemble records and data pertinent to the fire from all available sources.

2. Analyze these data from the standpoint of the study objectives. Search out important facts. Identify subject matter areas where more information is needed.

3. Interview key people involved in the fire.

4. Visit the site if significant additional data can be obtained.

5. Assemble a pictorial and audio record of key actions pertinent to the study objectives, i.e., on-site photos, copies of movie footage taken during the fire, 35mm slides, or tape recordings of key interviews.

6. Prepare and submit the report.

These steps are depicted graphically in Appendix G.

A more direct approach will be needed for studying going fires. For example, the team might proceed directly to Command Headquarters, get briefed on the situation, then plan their actions to meet

the objectives of the study. (See Appendix H for a list of equipment needed for studying going fires.)

There are 19 key problems that the fire analysts should gather information about. Listed in relation to the study objectives, these are:

RELATED TO OBJECTIVE NO. 1

1. MUTUAL AID ARRANGEMENTS - Pre-disaster and during disaster.
2. MULTI-ORGANIZATION COMMAND ASSIGNMENTS AND ORGANIZATION STRUCTURE - Pre-disaster and during disaster.
3. SUPPRESSION AND RESCUE RESOURCES INVENTORY, DISPATCHING AND LOCATOR SYSTEM - Pre-disaster and during disaster.
4. COMMUNICATION SYSTEM.

RELATED TO OBJECTIVE NO. 2

5. FIRE PROBLEMS THAT, IF SOLVED, WOULD STRENGTHEN ACTION.

RELATED TO OBJECTIVE NO. 3

6. PROTECTION OF KEY BUILDINGS AND STRUCTURES - Relate this to shelter fire safety.
7. COST-BENEFIT FACTORS IN STRATEGIC DECISIONS - VALUES SACRIFICED AND VALUES GAINED.
8. STRATEGIC RE-DEPLOYMENT OF FORCES TO PROTECT KEY AREAS.
9. EMERGENCY EVACUATION OF PEOPLE.
10. SYSTEM AND BASIS FOR ESTIMATING CONTROL FORCE NEEDS - Relate to timing of action.

11. CONTROL OBJECTIVES.

12. TACTICS AND EQUIPMENT.

RELATED TO OBJECTIVE NO. 4

13. PRE-DISASTER PLANNING AND PREVENTION MEASURES.

14. TRAINING OF OVERHEAD AND SUPPRESSION FORCES - Pre-disaster and during disaster. Training planned, training done, methods and equipment used.

15. FUEL CONDITIONS.

RELATED TO OBJECTIVE NO. 5

16. LOGISTICS AND ACTION TIMING. IMMEDIATE ACTION, FIRST HOUR ACTION, FIRST DAY ACTION - Relate to fallout probability.

RELATED TO OBJECTIVE NO. 6

17. FATIGUE FACTORS.

18. WEATHER CONDITIONS.

19. ADDITIONAL UNFORESEEN FACTORS THAT WILL ADD TO THE QUALITY OF PROJECT ORDER No. 83.

These problems are further defined for the fire analysts' benefit in Appendix B. Appendices B, C, D, E, F, G, H will aid the analyst in his study, in writing the report, achieve comparability between study teams.

IV. APPENDIX

A. Criteria for Fires to be Studied.

B. Problem Areas to be Studied.

C. Data Sheet - Large Fires.

D. Data Sheet for Interviews.

E. System for Interviewing.

F. Outline for Fire Study Report.

G. Graphic System for Studying a Fire.

H. Equipment Needed to Analyze Going Fires.

APPENDIX A

Criteria for Fires to be Studied

Fires studied should meet the following conditions:

1. It had a management problem.
2. It involves more than one agency.
3. It involves populated areas.
4. It involved more than 100 men or equivalent equipment.
5. It burned for more than one day.
6. There is likely to be data available for a meaningful study.
7. Period in time — any
8. Place — any
9. Size — any
10. Damage — any
11. Suppression cost — any

Disasters such as earthquakes or tornadoes, which included large fires, will be considered.

Situations where multiple fire starts in a broad area create serious management problems will be considered.

Selection will be made to include a "cross section" of varying complicated fire situations. The objective is to study a range of fires that will reveal data important to achieving the objectives of Project Order 83.

APPENDIX B

Key Problems to be Studied
(Study Guide)

I. MUTUAL AID ARRANGEMENTS

a. What were the pre-emergency arrangements?

b. How did mutual aid actually work during the emergency?
Were excuses made - people blame something for problems
Quality of people + equip.

c. Were the agencies mixed, or was each assigned a separate zone? Why?

d. Who arranged and dispatched the mutual aid? What was his position and authority? How did he get the authority?

e. What problems exist that prevent full fire suppression effectiveness?
How about liability? Indiv. insurance coverage? Who pays for costs after first shift?

f. How could the arrangements be improved?

g. Prepare an organization chart of assignments.
Theoretical + actual - could be different.

h. Were mutual aid agreements formal (written) or informal?
agreements may be made but not approved by local govt.

i. Do informal agreements still serve after 2 or more shifts, and serious conditions still exist.

j. What was the role of CD in these arrangements?

2. MULTI-ORGANIZATION COMMAND ASSIGNMENTS AND ORGANIZATION STRUCTURE

a. What were the pre-emergency arrangements?
expanding fire situation - i.e. from regular to zone fire boss w/GHQ or to coordinator multi-fire setup. Provisions for GHQ structure. Smooth transition desired.

b. How did pre-emergency plans actually work during the emergency?
Were plans consulted? Distributed to responsible fire services? Look for critical failure points.

c. Who was in command? Under what conditions? For what period? Why was he in command? How was he assigned?
How + Why are particularly important here.

d. What problems existed that prevented full effectiveness?
Simple, workable plans essential. Elaborate plans often unworkable. Was orgn. size mis-calculated? Too little, too late? Communications? Was effective liaison working?

e. How could the arrangements be improved? What, when, where?

f. Prepare Organization Charts showing Command Assignments.
actual vs. theoretical

g. Were top level decisions made jointly by several fire services' representatives or by one man? Were decisions made expeditiously?

were decisions accepted?

Diplomacy essential to get true facts here. One-man vs. joint decisions - how did each work? What were key events - how did decisions affect key events. What level can make decisions?

h. Were decisions made more easily as the situations worsened?
avoiding facing problems (sacrificing areas, etc) until moment of truth, when actual decision came easier.

i. What was the role of the CD organization.
was there formal involvement of OCD or OEP or was it just token? Did CD command, coordinate, or support - or just interlope

3. SUPPRESSION AND RESCUE RESOURCES INVENTORY, DISPATCHING AND LOCATING SYSTEM

a. What were pre-emergency arrangements?

b. How did they work during emergency?

c. How did they relate to command and mutual aid arrangements?

d. How did communications office keep informed about resources he had committed and those he could draw upon?

e. Get samples of systems and aids - include photos and detailed description.

4. COMMUNICATION SYSTEM

a. What was it? Describe it.

b. Was it effective? Explain.

c. What problems exist that prevent it from being fully effective?

d. Depict the network graphically if possible.

e. What additional communications hardware would have helped? A mobile unit? A portable facility? A more sophisticated system?

f. Were better operating procedures needed? Better radio discipline?

g. Could the various fire services communicate? What was needed?

5. FIRE PROBLEMS, THAT IF SOLVED, WOULD STRENGTHEN ACTION

a. Identify and list those pertinent to the objectives of Project Order 83.

fallout shelter integrity
communities' capability to deal w/ potential fire spread
preplanning embracing direction + coord. of urban, suburban, rural fire services

b. Describe and define each problem.

be sure definition of problem is clear.

6. PROTECTION OF KEY BUILDINGS AND STRUCTURES

a. Relate this to protecting shelters.
If there a shelter in bldg - is it protected, sealed against smoke + CO

b. What effective tactics were used?
sacrifice some to save some - flood + run - smoke + fume control in addition to heat -

c. What decisions were especially timely and important?
look for key decisions - who made decisions

d. Who made the strategic decisions to protect or abandon key structures?

e. Who made the tactical decisions?

f. Explain any experience important to protection of people in shelters. Smoke + fume protection. Should give protection for about an hour - learned from nuclear/fire studies.

g. What pre-emergency measures were effective in saving structures?
water supply - alt. escape routes -

h. What measures are suggested by this fire?

i. Evaluate the fire hazard of shelter spaces in burned structures, in threatened structures, in other similar or nearby structures.
how about lack of oxygen - pilot lights gone out ?

j. How could the shelter spaces be better defended from fire?
emerg. power supplies - food - water - sanitation.

k. What factors caused the fire threat to these shelter spaces? What problems would shelter occupants face and what should they do if threatened by this fire under fallout conditions?

7. COST-BENEFIT FACTORS IN STRATEGIC DECISIONS-VALUES SACRIFICED AND VALUES GAINED

a. What values were knowlingly sacrificed?

grocery store vs. drug store - school vs. hospital, etc
nat. art gallery vs. US capitol, etc.

b. Why were these sacrificed?

c. Who made the decision to sacrifice values?

d. What values were gained?

e. What tactics were especially effective in saving values?

f. Were priority guidelines available? Would they have been helpful?

g. What pre-planning measures were effective in the control of this fire? Compare costs of pre-attack measures with values saved.

h. What would have happened if there had been no control effort?

i. What measures reduced the spread? Fire walls, fire doors, sprinkler systems?

8. STRATEGIC REDEPLOYMENT OF FORCES TO PROTECT KEY AREAS

a. What were the key areas?

prearranged on plan - priority established

b. Why were the Forces redeployed?

c. How were they redeployed?

key history of fire onto maps - include redeployment.

d. Who made the decision to redeploy?

was there a chain of command? was it followed? use of bold judgement to sacrifice areas to gain control of strategic points.

e. What forces were involved?

f. Was the redeployment successful? Strong points? Weak points?

what happened in fire areas where forces were diverted from?

g. Was access adequate? Describe. What was or could be done about it?

assistance from law enf. agencies - evaluate.

9. EMERGENCY EVACUATION OF PEOPLE

a. Why were they evacuated?

b. How was the evacuation done? Was it successful? Why?

c. Who made the decision to evacuate them?

d. How many were evacuated? How far? From where to where?

e. What equipment was used?

f. When was the evacuation carried out? Relate to timing of emergency.
see h. below

g. What problems exist that prevented the evacuation from being fully successful?
traffic jams - blocked roads -

h. What legal authorities are responsible for evacuation?
was disaster area proclaimed - by who - when - what were results of proclamation

i. Did evacuation affect control action of the fire? Movement of equipment? Was it over dead-end or through roads?

j. Was firefighting equipment used to help evacuate people? What equipment was used? What agencies helped? Could more civilian equipment and volunteers have been used effectively?

10. SYSTEM AND BASIS FOR ESTIMATING CONTROL FORCE NEEDS

a. How were needs estimated? Upon discovery? Reestimates after discovery? Who did it? What factors were considered? How effective were the estimates?

Size, location, ROS, weather, fuel type, manpower/equip. avail, were control objectives met

b. What equipment and aids were used?

tables, computers, experience

c. How was the information gathered for the estimate?

personal scouting - line OH interviews, LO's, IR, TV, etc

d. What factors inhibited gathering complete, sound information.

smoke, night visibility, wind, lack of orgn., jargon used in reporting, lack of checklists,

e. How did the commander get the information about the "on the line" situation?

pers, line overhead interviews, etc

f. Get copies of aids and guides.

g. Was there a central collection point or command center for evaluating information?

h. Was there duplication and gaps in information?

requires post-fire analysis

i. How could the system have been improved with the facilities available?

j. What additional facilities or personnel would have helped?

could people have filled any gaps

k. Would the basis for estimating control have been adequate for a nuclear situation?

consider fallout - time, amount

Example - if say 20 ignitions occur and 3 engine cos. can work for 1 hr before fallout arrives, what were objectives of their actions? Who decides, etc.

II. CONTROL OBJECTIVES

a. What were they?

Scope - broad to narrow. - were objectives valid or realistic, adjusted to fit changing needs.

b. Who decided what they were to be?

fire boss - local - distant govt.
rely on staff judgements

c. What factors were used in setting them?

location, size, behavior, rate of spread, weather, fuels, photography, barriers, values, equip, assistance, legal, political

d. Were they achieved?

try to get copies of written orders - were objectives changed to meet new needs?

e. What key factors contributed to or detracted from achieving them?

see c above - also, adherence to outmoded objectives - can be very wasteful.

f. Did key people know them? Were they committed to them?

written orders - logs of briefing - say how estimate of commitment was derived (subjective or evidenced).

g. Would these objectives be realistic in a nuclear situation?

arrival time of fallout should be considered - would fallout have made a difference

TACTICS AND EQUIPMENT

a. Identify and explain the tactics and equipment that was especially successful or tried and proven to be of no value in controlling the fire, in evacuating people, in Pre-fire planning or which is important to any of these 19 key probelms?

b. What equipment used here would have application elsewhere? Peacetime? Nuclear fire?

c. What equipment from other regions could be used here?

d. Was private equipment used to good effect? In suppression action? In support and supply? In the evacuation?

e. Was urban fire equipment suited to the job of mixed structure and natural fuel fires? How could it be supplemented?

13. PRE-DISASTER PLANNING AND PREVENTION MEASURES

a. What was done before the fire occurred that contributed to successful fire control?

Were people trained? Mutual aid agreements. Was one boss designated or coord. team? How tasks? Were pre-fire assignments made? Had prelim. problem analysis been made? Water supply vulnerable? Had priorities been made (save vs. sacrifice?). Rehearsals? Communications / equip. compatibility?

b. How did it contribute to control?

Was action quicker because of agreements? Were plans made but didn't work (maybe because locals didn't help in plan prep.?)

c. What happened on the fire that indicated need for additional or different pre-disaster action?

Lack of knowledge by participants

d. Describe access roads, fuel-breaks, fire-breaks, fuel type conversion measures that were effective. Could they have been more effective with better tactics?

Traffic jams - narrow or blocked roads? Was traffic mgmt pre-planned? Urban areas need fuel breaks, too - can be freeways, parking lots, parks, etc provided they are linked together to form fuel breaks. City planning - Did fire agencies know how to use fuel breaks

14. TRAINING OF OVERHEAD AND SUPPRESSION FORCES

a. What training was done?
pre-fire – and during fire, if any.

b. How did the results show up on the fire? look particularly at activities in transition zones – i.e. rural crew working in urban area, etc

c. Did citizen volunteers help with suppression? Were they trained? delay until post-fire interview.

d. What additional or different training would have made control more effective?
structured training for rural firemen – equipment – use of full-scale mock field problems.

e. What training methods or equipment was used?
classroom, field, OST, aids, simulation, etc

f. Who did the training? Did fire agencies train together?
was training formal or informal: man-to-man. In joint training sessions was training focused on actual joint opn. methods, or was it within indiv. agency cocoons?

g. Were both urban and rural firemen used? Were both services trained in both types of fire?

h. Could volunteers have been organized for more effective work?
check pre-fire organizing and during fire orgn.

i. Was time taken for on-the-job training during the emergency? What training was done on site of the fire?.
look for specific training assignments, not just "osmosis".

j. Did ~~inadequate~~ training affect the tactics employed? Did it affect strategy? look for key fire mgmt failings and/or examples of good mgmt. Very sensitive area – use diplomacy.

15. FUEL CONDITIONS

a. What fuel conditions made control most difficult?

fuel moisture, fuel types

b. What conditions enhanced control most?

separations - treatments (treated shingles, for instance).
color of paint on bldgs (white vs. black)

c. What could have been done in advance to improve fuel conditions? What was done?

shelters in basements - fireproof doors in stairwells - treated roofs,

d. Were structures and natural fuels contiguous? What could have been done, or had been done?

cleanup around or in houses

e. Would the removal or treatment of ground fuel have kept the fire from moving in the crowns or aerial fuels?

"For the want of the nail, the shoe was lost" -- etc

16. LOGISTICS AND ACTION TIMING

a. What immediate action seemed most effective?
consider initial attack

b. What first hour action was most effective?
consider initial attack

c. What first day actions were most effective?
command coordination - impact of preplanning on effectiveness

d. Why did first hour action fail to control the fire? - First day action?
physical elements - comm., word.,

e. What could have been done to control the fire in the first hour? First day?

f. Relate these to fallout probability.

g. Could the action have been more selective as to protection of vital improvements such as shelters?

h. What first day actions or lack of action contributed to delayed control?

17. FATIGUE FACTORS

a. When did they show up? (when they began to have significant effect on suppression).

b. How did they affect control?

compare results w/ calc. of probabilities for days.

c. What was done about them?

shorter shifts, rest periods, spike camps on line, helicopter shuttle, rotation of crews.

d. Was the fatigue more obvious among firefighters, intermediate overhead, or top management? Why?

line workers respond quickly to rest periods - top mgmt doesn't respond too quickly - can't get mind off problems.

18. WEATHER FACTORS

a. What was the weather situation?

what is usual weather in area - were there any variations during fire period?

b. How did weather effect the fire?

Did weather effect operating force - people or equip?

c. Were the forecasts as reliable as can be expected?

spot forecasts used? made by regular meteorologist or fire weather forecaster?

d. Were the forecasts used effectively in planning control and other action? Could more use have been made of the forecasts?

e. Were more and better forecasts needed?

spot forecasts?

f. Could pre-emergency forecasts have been more effectively used to initiate action that would have prevented the ignition, or enabled earlier control?

19. ADDITIONAL UNFORESEEN FACTORS

This guide is not comprehensive. It poses some leading questions about each problem to help the analyst get started.

The analyst should study and include any factors which he believes pertinent to the project.

What would have happened if no supp. action done?

To fill gaps in the fire studies made to date, information is particularly needed on the following:

A. What was the Civil Defense role in mutual aid arrangements?

B. Samples of dispatching aids, detailed descriptions and photos of inventory, dispatch and locator systems.

C. In the protection of key structures;

1. What pre-emergency measures were effective?

2. What protection measures were effective?

3. Examine shelters in areas similar to the area burned. Describe the fire vulnerability. What would have happened to occupants if the fire had occurred in this area? What measures could be taken to safeguard the shelter occupants? By the occupants? By the fire services? Others?

4. How would fallout affect these measures?

D. What would have happened in the absence of control action? Calculate probabilities.

E. Was access adequate for evacuation? For control action? For the whole job?

F. The entire item #10 on system for estimating control force needs.

G. Would the control objectives have been realistic under a nuclear situation?

H. The entire item #15 on fuel conditions.

I. Relate the logistics and action to fallout probability.

J. Could the action be more selective in protecting key facilities?

Was it necessary to establish priorities for control? How was it done?

K. Was a multi-agency coordinating center established early? How?

L. Examine urban fire spread.

1. How did fire spread between structures? Through natural fuels? By radiation? By fire brands alighting upon them? Distances?

2. How could burning structures be isolated from others ? By action at the time? Pre-emergency action?

3. How were threatened structures saved? Action at the time? Pre-emergency action?

APPENDIX C Author _____

Date _____

DATA SHEET - LARGE FIRES

Name of Fire _____ Date of Fire _____

Location of Fire _____

State _____

Unit _____

Other _____

Responsible Agency _____

Area Burned _____ Urban Acres _____ Suburban Acres ____

Rural Acres _____

Period of Fire, From _____ To _____

Damage: Forest _____ Watershed _____

Structures _____ Total Damage _____

Casualties _____

Values Threatened _____

_____

Why did this fire get large? _____

_____

_____

Forces Engaged:

Units _____

Firefighters _____

(See Section 2 of the Report)

APPENDIX D

DATA SHEET

Name of Fire_____ Date of Fire_____

Interviewee_____

a. Address and Phone No._____

b. Organization & Position_____

c. Assignment on this fire_____

Interviewer_____ Date of Interview_____

Information developed during the interview:

APPENDIX E

SYSTEM FOR INTERVIEWING

(To be developed)

APPENDIX F

OUTLINE FOR FIRE STUDY REPORT

1. Description of how the Analyst conducted the study.

2. Description of the fire

   a. Location
   b. Size & damage
   c. Casualties suffered, if any
   d. Fuels, topography, and weather
   e. Control time required
   f. Rate of spread during worst period
   g. Men, equipment, water and chemicals employed, total. Peak Load.
   h. Agencies and fire services engaged in suppressing the fire.
   i. A summary statement describing briefly the type of a fire it was.

3. Analysis of the Situation

   a. Analyze, synthesize, compare and relate all data collected in the study.
   b. Describe and depict these so they can be related to the objectives of the study.

4. Findings, conclusions, and assumptions. Using the analysis of the situation as a base, describe briefly what has been learned from studying this fire. List the conclusions and assumptions made by the analyst.

5. Recommendations

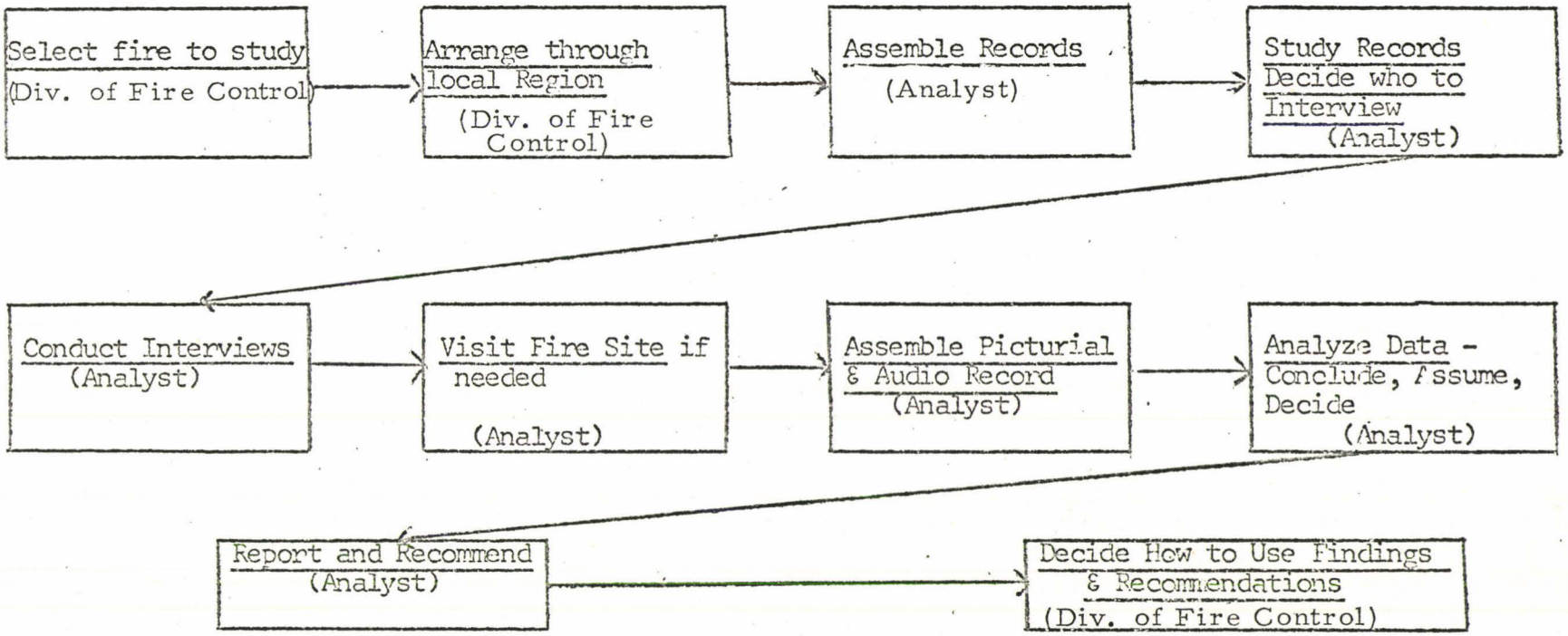
   a. List promising areas for adapting to a nationally coordinated fire service.
   b. Describe problems, that if solved, would increase effectiveness.
   c. Include additional recommendations pertinent to Project Order 83.

6. Appendix

   a. List of persons interviewed.
   b. Maps and charts
   c. Photos, tapes, movies, slides, etc.
   d. Other

APPENDIX G

SYSTEM FOR STUDYING PAST FIRES



APPENDIX H

EQUIPMENT NEEDED TO ANALYZE GOING FIRES

(To be Prepared)

1. Transportation:
   - TR book
   - Know travel regulations
   - GSA Pool
   - Hertz Credit Card

2. Camera, black and white prints

3. Telephone procedures

APPENDIX I

PROJECT ORDER 83

Wash DC
8/16/67

OCD Fire Analysis Training

Dave Gratz — Silver Springs Md Fire Chief — represents Natl. assn. Fire Chiefs, urban type firefighting.

Jim Jay — reasons for analysis — result of Natl. Fire Coord. Study. in all of last wars, all powers used fire as weapon. Nuclear attack damage - blast, fallout, fire. Natl. fire coord. Study made several recommendations, of which DOD implemented 11. Proj. 83 is sample state and city fire plan preparation - 2 yr study by WOFC.

Assume that trainees already can

analyze & report
interview people
collect info
organize
synthesize

—

—

Usual fire analysis takes 2-5 days in field for 1 to 2 man team.

—

Objectives: to develop uniformity of analyses & reports, aimed at meeting needs of proj. 0083.
Provide an overview of procedures.
You will be able to relate findings on peacetime fires to possible nuclear situations.

Bjornsen - underlined words are "coathooks" upon which larger knowledge is hung.

Role has now changed from fire doer to fire analyst, who must pull out plums of wisdom from mass of events. Must be objective, try to overcome preconceived notions.

Need facts, not my or other opinions of what happened. In fact gathering process, analyst becomes an interloper in doing fire organization. In this capacity analyst must use diplomacy. Analyst must assess impact of his presence on doing fire orgn, try to minimize (i.e. provide own transportation, otherwise often slow of being there).

Focus attention on key items - this will allow peripheral items to fall in place.

Heilman
8/16/67

Pre-Disaster Planning Drill

1. list 5 pre-disaster actions
   a. communications interface
      frequencies
      area coverage
      power supply - emergency
      etc
   b. equipment compatibility
      hose fittings
      adapters
      fuel types (gas vs. diesel vs. butane, etc)
   c. personnel directory
      names - alternates
      phone nos. - day & nite
      addresses
   d. plan preparation
      who does what
      where
      when
   e. plan rehearsal
      trial runs
      indicated tuneup actually made

Kilmer
8/16/67

Mutual Aid Arrangements Quiz

1. Who is boss of mutual aid?
   as agreed upon by participants – usually the chief of area where action occurs, but better qualified "outsider" could be named on occasion.
2. Who should designate boss of mutual aid?
   mutual aid participants – usually the local responsible agency head or governing body.

3. Why have mutual aid arrangements?
   in order to provide capability beyond local resources or abilities.

DEFENDING THE UNITED STATES FROM NUCLEAR FIRE

A RESUME' of the Final Report of the

National Fire Coordination Study

DIVISION OF FIRE CONTROL/FOREST SERVICE/U.S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

AUG 1966

The National Fire Coordination Study was conducted by the Forest Service, U. S. Department of Agriculture, for the Office of Civil Defense under Project Order OCD-PS-64-229. Its objectives were to:

1. Review pertinent research findings and define the nuclear fire problem.

2. Recommend a nationwide fire defense program, including alternatives, for the Office of Civil Defense.

3. Recommend how the several parts of the fire defense program should be implemented.

This paper is a resumé of the final report.

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DEFENDING THE UNITED STATES FROM NUCLEAR FIRE

A resumé of the final report of the National Fire Coordination Study

By

William R. Moore, James W. Jay, and John H. Dieterich

INTRODUCTION

During World War II all of the major powers used fire to inflict destruction upon their adversaries. Fire gutted communities, took lives, and destroyed resources. In July and August 1943, Hamburg, Germany, was more than half destroyed by aerial bombardment; three quarters of the damage was by fire.

Fire devastated many cities during the war. From a scattered haphazard beginning, fire use developed into planned incendiarism that was primarily responsible for urban destruction. The climax came with the atomic attacks on Hiroshima and Nagasaki. Here two great cities were almost completely eliminated by the fire and blast from a single bomb dropped on each. Meanwhile, American cities and countrysides remained undamaged, quite removed from the threat of war.

In this day of intercontinental ballistic missiles and thermonuclear warheads, an attack could quickly convert the bustling peacetime American scene into embattled front lines. If this happens, could the fire services control the fires while hampered by rubble, broken water mains, and radioactive fallout and harrassed by numerous thermal ignitions? Studies made of large fires during the past few years indicate that in many cases they could not. What then can be done before, during, and after an attack to confine the damage from nuclear fire to acceptable proportions? This heretofore unanswered question prompted the National Fire Coordination Study, conducted by the U. S. Forest Service for the Office of Civil Defense (OCD).

Cooperating in the Study from the beginning were experts from urban and rural fire services, supporting groups, and fire educational organizations.

The Study

The Study began in July 1964 with orientation meetings in Los Angeles, Portland, Chicago, Boston, and Memphis among urban and rural fire leaders and other interested persons. Later, related operational studies were reviewed and their recommendations considered. To obtain samples of present fire planning and readiness activities, fire mutual aid arrangements were studied in California, Oregon, Michigan, Massachusetts, and the Washington, D. C., Metropolitan Area. Tactical fire control practices and problems were examined and related to the defense of fallout shelters by studying 12 large fires. Nuclear attacks of varying degrees and types were hypothetically employed upon the United States to define the scope and complexity of the nuclear fire problem. Pertinent research findings were then summarized and applied to the attacks.

Thus, the Report brings together research in nuclear fire and damage potential from attack, information from mutual aid, large-fire, and administrative studies, and the thinking of many fire leaders across the Nation.

THE PROBLEM

Damage from a nuclear attack would be caused primarily by blast, radioactive fallout, and fire. Fires would be started by thermal flash from the nuclear warheads and by broken power lines, overturned stoves, and similar disruptions resulting from the blast. Blast causes severe destruction in a limited area but is incapable of spreading beyond the area of initial damage. Radioactive fallout and fire not only inflict damage in the blast area, but spread beyond to threaten additional lives and resources.

Climate and weather, spacing and flammability of fuels, and to a lesser extent topography influence the ignition and spread of fire. The most serious fire threat would develop from many small fires burning together and creating large fires capable of threatening fallout shelters and needed resources.

What, then, can be done before, during, and after an attack to reduce the damage from nuclear fire?

Because lethal doses of radioactive fallout from a nuclear attack could cover large areas of the United States, the fallout shelter program is recognized as the most fundamental life-saving measure in Civil Defense. After an attack, however, spreading fire could threaten some shelters and force survivors to defend the shelters or expose themselves to fallout in order to escape the fire. These shelters must be protected, whether from fires starting within the shelter, spreading from other buildings, or spreading from forest fuels. Depending upon weather conditions and size and nature of attack, as much as 10 percent of the land area of the United States could burn. (fig. 1)

ATTACK EFFECTS ON TOTAL LAND AREA OF THE U. S.

ON A GIVEN CLEAR DAY IN AUGUST

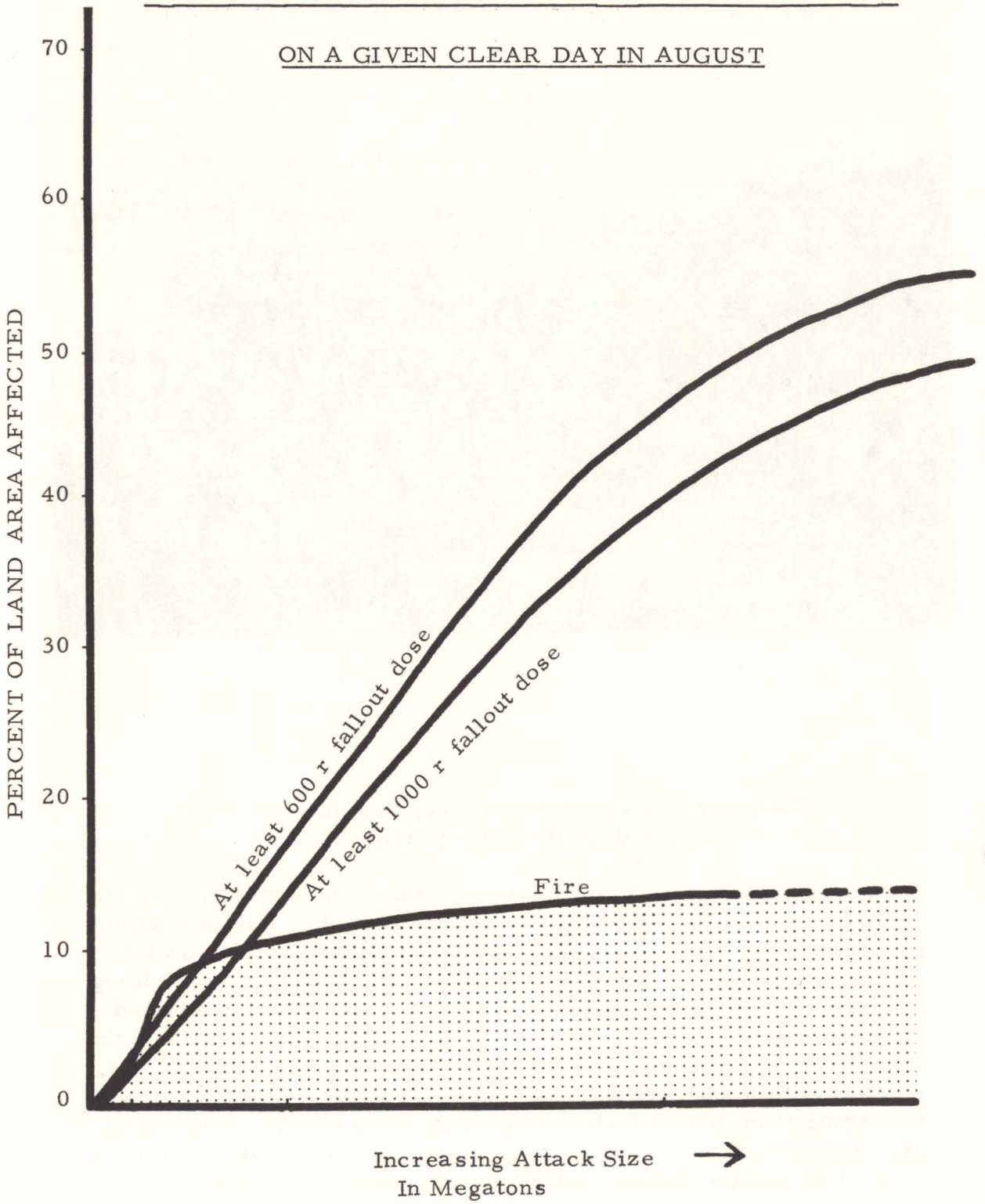
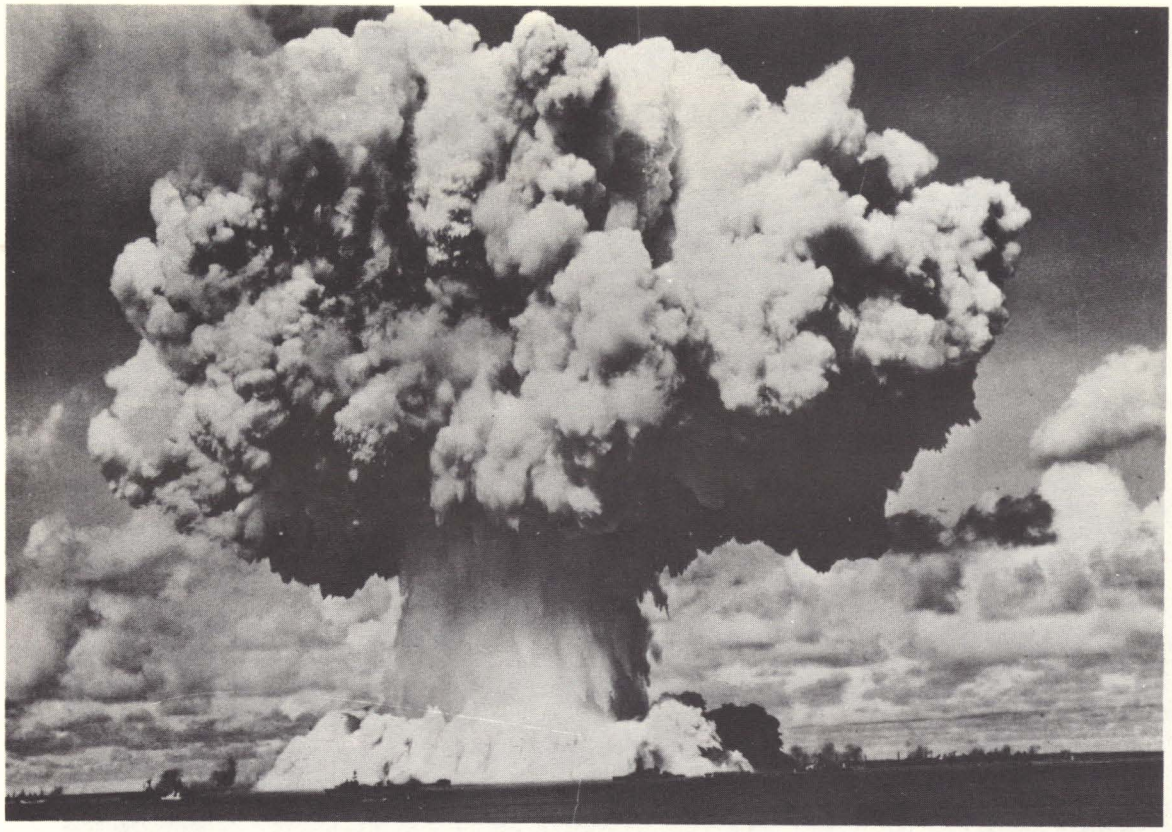


Figure 1

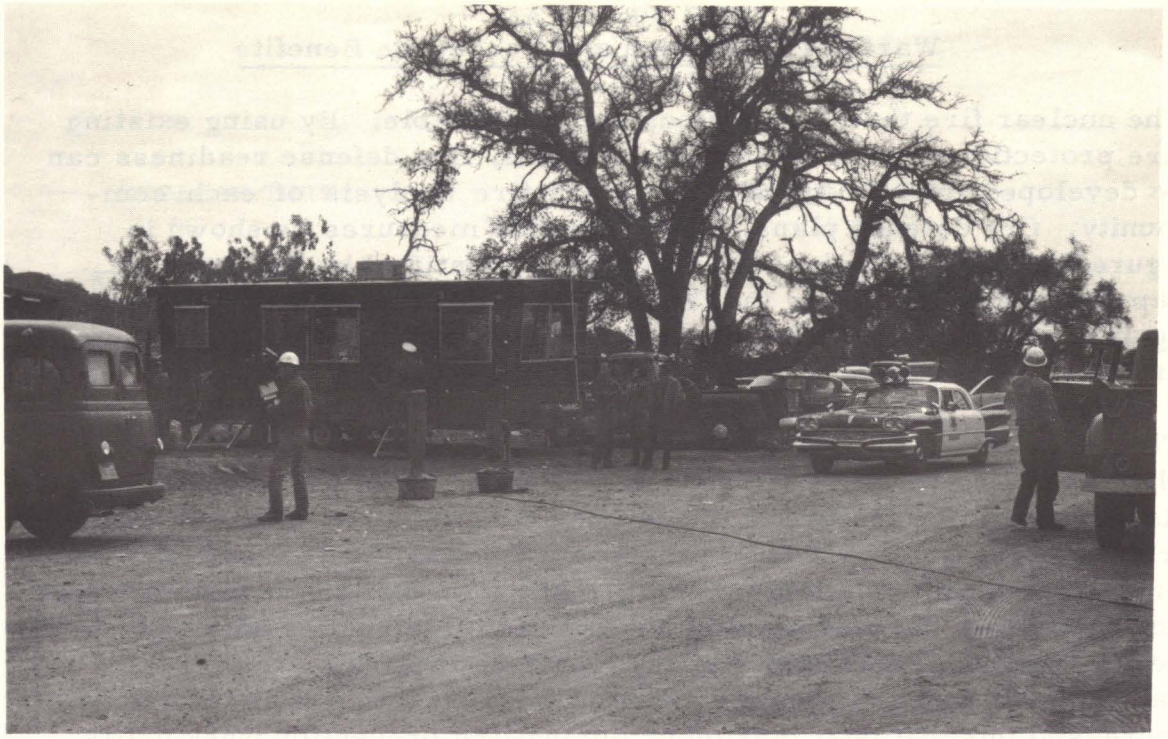
"Tactical fire control practices and problems were examined and related to defending fallout shelters by studying large fires."



Damage from nuclear attack would be caused primarily by blast, fallout, and fire.

Wartime Fire Defense Differs From Peacetime

The most serious complication introduced by nuclear weapons is fallout that could interfere with firefighting and the movement of people. The presence, anticipated presence, and duration of radioactive fallout would control the timing of any activities outside the protection of fallout shelters. Also, broken water mains and rubble would reduce the effectiveness of conventional firefighting equipment. In some areas fires would be so numerous that available trained firefighting forces would be quickly overwhelmed if they attempted to control them all. Consequently, fires that threaten lives or resources needed for survival must receive priority. Citizen action to remove combustible materials, cover ignitable home furnishings, and to put out small fires are an important auxiliary to organized fire defense.



Urban and rural fire forces would be joined together – much oftener than they are in peacetime – to fight the common enemy, nuclear fire.

Disaster areas created by nuclear attack would be so large that urban and rural fire forces would need to join together – much oftener than in peacetime – to fight the common enemy, nuclear fire. This requires joint urban-rural planning and training, especially in areas where rural fuels capable of spreading fire are adjacent to urban areas.

Expanded Capability is Needed

Organized fire services in the U. S. are effectively protecting urban areas and all but about 500 million acres of rural land. Personnel of these services are competent firemen, equipped and trained to act independently and effectively. Given guidance, support, and training in nuclear aspects of fire, they can provide fire defense leadership to the public and take preparedness, selective fire control, and related rescue actions that will reduce significantly the nuclear fire threat. The foundation of our Nation's strength for fire defense in nuclear war is the organized fire service. These firemen, and the populace, must face the fire threat independently until it is possible to arrange aid to stricken communities. Understanding by both public officials and citizenry of the size and complexity of the nuclear fire problem is the first step toward reducing the fire threat. Such understanding is not widespread in the U. S. today.

THE PROGRAM —
Wartime Protection and Peacetime Benefits

The nuclear fire threat is serious but manageable. By using existing fire protection capability as the foundation, fire defense readiness can be developed through training, special fire analysis of each community, fire defense plans, and protective measures as shown in figure 2. The protective measures were identified by the Study as capable of supplementing the fire services in preparation for defense against nuclear fire. They form the proposed nationwide fire defense program (table 1).

The program would begin with issuance of nationwide guidance (part E, chapter 10, Federal CD Guide). A minimum number of citizens and firemen would be trained to protect shelters and critical resources from nuclear fires. OCD would sponsor national-level leadership training, prepare and distribute training materials and aids to fire services and organizations, and develop TV and radio instruction kits to be kept ready at national networks and key locations in each state. The TV and radio instruction kits would be used to instruct citizens on occasions of increased international tension or during fire prevention week drills.

A special nuclear fire analysis system is recommended that would provide planning data for each community. Nationwide planning efforts would be guided by a National Fire Defense Plan.

Development of an infrared mapping system _ to become part of a nationwide intelligence system — would continue. Special studies would provide data for developing nationwide intelligence and communications systems. A system for assessing damage from nuclear fires would be installed. OCD would prepare guides for community planning to eventually reduce the fire vulnerability of cities.

The fire vulnerability of each community fallout shelter would be determined by inspection. Corrective action would be included in a fire defense plan for each shelter. As necessary, fire suppression equipment and auxiliary water would be placed in each shelter, and a fire guard trained to help the shelter manager carry out the fire plan. When indicated by the inspection, corrective action would include fireproofing the roofs of buildings that house shelters.

Fire control and associated rescue during a nuclear attack would be strengthened through training, air operations, and improved fire resource locator equipment.

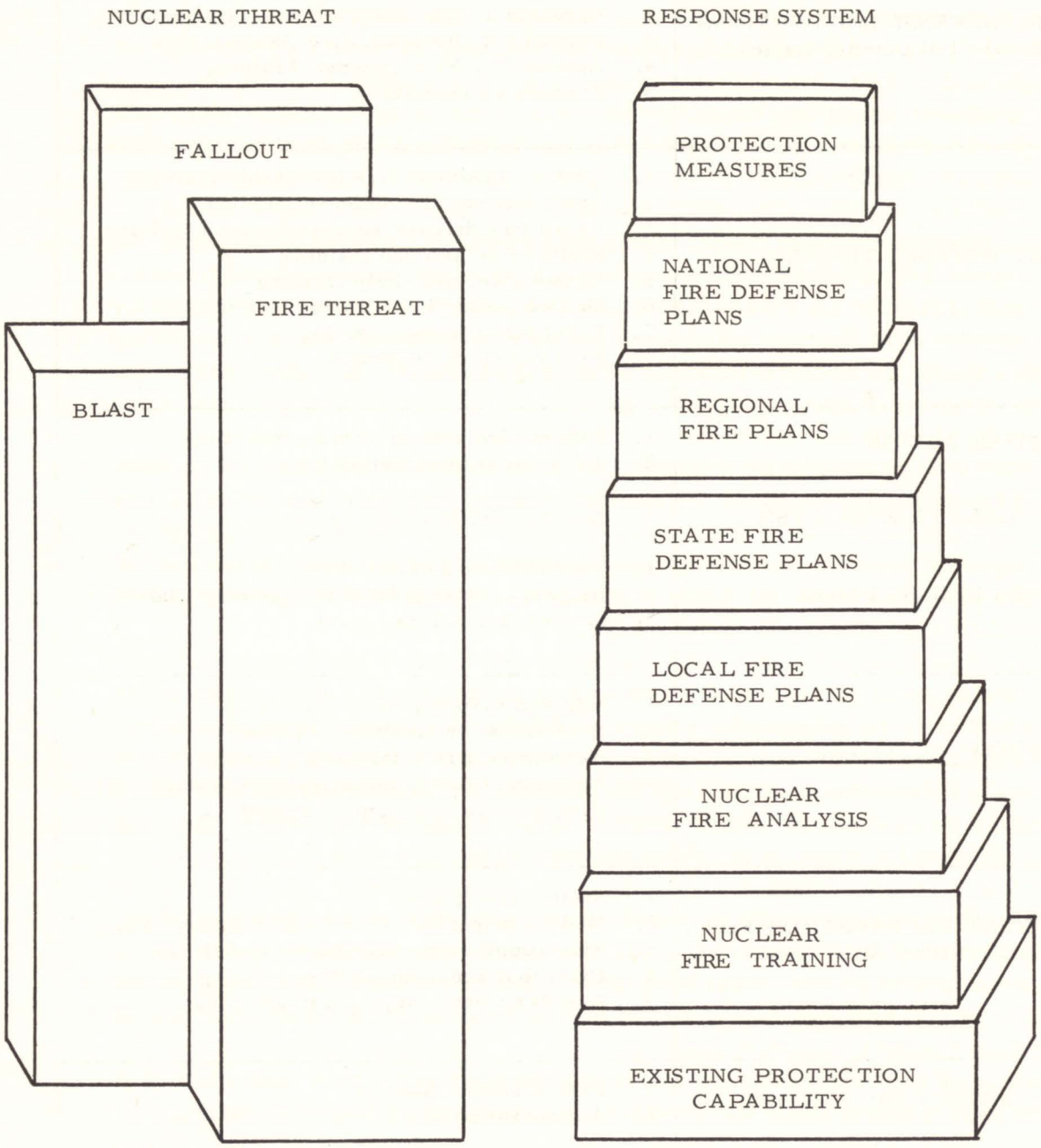


Figure 2 The response system, with components based on the existing capability, must equal the nuclear fire threat.

Table 1

PROPOSED COMPONENTS OF THE FIRE DEFENSE PROGRAM

-FIRE DEFENSE INSTRUCTIONS (Federal Civil Defense Guide)	1. Part E, chapter 10, Fire Defense 2. Appendix 1, Nuclear Fire Analysis System 3. Appendix 2, National Fire Defense Plan 4. Appendix 3, Fire Defense Training 5. Annexes as necessary
-FIRE DEFENSE TRAINING	1. Advanced nuclear fire leadership training 2. Basic nuclear fire defense training 3. Urban fire defense support fireman training 4. Shelter fire defense training 5. Householder self-help training 6. Shelter inspection & rating training 7. Rural fire defense training 8. Fire research seminars
-CITIZEN ACTION	1. Citizen fire extinguishing prevention 2. TV & radio information kit
-NUCLEAR FIRE ANALYSIS	1. Nuclear fire analysis system
-FIRE DEFENSE PLANS	1. National fire defense plan 2. Regional, State & local fire defense plans 3. Shelter fire defense plans
-SUPPORT ACTIVITES	1. Infrared mapping of nuclear fires 2. Guidelines for community planning 3. Nationwide fire intelligency system 4. Nationwide fire communications system 5. Fire damage assessment system
-SPECIAL PREPARATIONS FOR DEFENDING SHELTERS	1. Shelter fire guards 2. Shelter inspection & fire vulnerability rating 3. Fire suppression equipment in shelters 4. Fireproof roofs for shelter buildings 5. Auxiliary water supplies in shelters
-EMERGENCY OPERATIONS	1. Fire resource locator 2. Air operations

When fully implemented, this program would reduce the threat from nuclear fire to acceptable limits and would reduce losses of life and property experienced in peacetime. It would harmonize with the objectives and procedures of other Civil Defense endeavors.

JOINT ACTION IS NEEDED

Because potential nuclear fire is both a local and nationwide threat, the combined efforts of OCD, the fire services, fire supporting groups, fire educational organizations, industry, Federal, state, and local governments and citizens are needed to implement the fire defense program. But support and participation in the program cannot be expected until the participants understand the nature and extent of the nuclear fire problem and its relationship to peacetime fire activities. Thus, as a first step, it is necessary to conduct basic nuclear fire defense training.

National leadership is necessary to coordinate the work of each participant with the program's objectives. This leadership will be by the Departments of Defense, OCD, and Agriculture, FS, as required by the Federal Civil Defense Act of 1950 as amended, and by Presidential executive orders issued to each Department.

The National Fire Defense Plan would describe responsibilities, objectives, and organization of fire defense activities at all levels of government. It would describe alternative methods of organizing fire operations at emergency operation's centers to permit expansion as required. Fire defense coordinators are recommended by the Study for local jurisdiction, for zones within the states, for states, inter-state regions, and at national headquarters. Coordination of readiness activities would be further enhanced by establishing a National Fire Defense Advisory Committee to advise the Office of Civil Defense. The existing Rural Fire Defense Committee, which advises the Forest Service, would continue as a sub-unit of the National Committee.

A Mutual Aid Policy is recommended to encourage states to enact legislation permitting governors to authorize easy interchange of fire forces and personnel within each state and between states. The policy would encourage mutual aid and training between urban fire services, state and local rural fire services, and Federal fire services. It includes cost sharing by OCD for planning extraordinary arrangements for nuclear fire.

THE TASK AHEAD

Although important fire defense efforts are already underway, substantial additional preparations are necessary for the proposed program. Before training can begin, materials and aids for training firemen, citizens, and civil defense officials must be prepared and tested. Ways to evaluate the results of training must be arranged. The Nuclear Fire Analysis System has to be developed. To make the National Fire Defense Plan fully effective, sample local plans should be prepared and made available to the states. Guidelines for inspecting and rating the fire vulnerability of fallout shelters are necessary, as are plans to guide the development of nationwide fire communications and intelligence systems. Infrared mapping, the fire resource locators, and use of aerially delivered fire retardants in urban areas require additional development. Several important fire annexes to the Federal Civil Defense Guide remain to be written. Moreover, to solve special problem and strengthen fire defense, continuing research is needed.

How rapidly should the fire defense program be implemented? There are many complex tasks. It is necessary to begin now to be fully underway 3 years hence, and there would be much work after that to achieve the full potential of each measure. Our Nation's security is partly at stake. Time is important. And in this nuclear age, time waits for no country.

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BOSTON FIRES

National Fire Coordination Study

U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/DIVISION OF FIRE CONTROL

BOSTON FIRES

- A study of four large fires and a projection of their threat to life and resources had they occurred during a nuclear attack.

A Working Paper Prepared

By

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June 1965

Reviewed by:

M. S. Lowden
W. R. Moore
J. W. Jay

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ACKNOWLEDGEMENTS

Personnel at the Headquarters Station of the Boston Fire Department were especially helpful in providing background information on fire development and suppression problems, estimates of fire spread, and on-site briefings for each fire. Particular thanks to John Clougherty, Andrew McElaney, and Mike Laurano.

Mr. John Leary, Information Officer with the Boston Office of Civil Defense, provided shelter data, maps, and some helpful advice.

BOSTON FIRES

INTRODUCTION

Background work for the National Fire Coordination Study, Project 229, calls for the study of large fires in urban areas, and in areas where the settlement pattern is mixed urban and rural. These studies are designed to search out factors important to better utilize Federal, state, local, and private fire organizations in effective control of mass fires resulting from natural causes or from an enemy attack.

Most peacetime fires in urban areas are far from being representative of the fires that might result from an enemy attack. However, they provide a realistic set of circumstances for evaluating the ultimate threat to the people and resources in the immediate area where the fires occur, thus providing some measure of what might be accomplished through the efforts of an organized fire service.

One of the major findings in the Analytical Report[1/] was that fire would be a significant causative agent in the loss of lives and resources in a nuclear attack. With the population in residences,

---

1/ Analytical Report, by W. R. Moore, J. W. Jay, J. H. Dieterich. NFCS, FS, Mar. 1965

fire would be less significant since a larger percentage of the people would loose their lives as a result of blast and fallout. Conversely, with shelters available and occupied, more people will survive the immediate effects of blast and the longer term effects of radioactive fallout. They would then be threatened by the fires that would result from the thermal effects of the weapons or the secondary ignitions caused by blast damage.

With these considerations in mind it was decided to study four recent large urban fires that have occurred in Metropolitan Boston, and assess these fires in terms of what can be learned and applied to the objectives of the National Fire Coordination Study. This study of the Boston fires was not made for the purpose of reevaluating the fire suppression strategy or tactics, or effectiveness of mutual aid response. Listed below are four fires that were examined:

1. The Bellflower Street Fire, May 22, 1964
2. The Codman Square Fire, October 12, 1963
3. The Morgan Memorial Goodwill Industries Fire, October 12, 1963
4. The Charlestown Fire (Potato Sheds Fire) May 10, 1962

Figure 1 is a map of the Boston area showing where the fires were located in relation to the city center, and in relation to each other.

STUDY OBJECTIVES

The main objectives of this Boston fire study are to project the case histories of these fires into conditions of fallout created by an assumed nuclear attack; and examine the resultant fire threat and demands on the fire services with particular emphasis on the problem of defending fallout shelters from fire. More specifically, the following points were considered:

1. What effective fire suppression action could be accomplished in a one-hour period before critical radioactive fallout arrived?

2. What is the fire threat to a sheltered population in areas adjacent to the fire?

3. Would multiple ignitions caused by the thermal flash create a situation that could be handled in the first hour - handled at all?

4. Would evacuation be possible or desirable under the assumed conditions of attack?

5. How far would the fire be expected to spread before being stopped by natural barriers?

6. Could fire control priorities be established to limit fire development in certain areas?

Figure 1. Location of 4 study fires in Metropolitan Boston.

DESCRIPTION OF BOSTON URBAN FUELS

Boston is recognized as one of several large cities in the United States having a major conflagration potential[2/]. In 1929 the National Fire Protection Association prepared a map of Boston, and surrounding boroughs, showing the potential conflagration areas. The map outlined the areas where building densities exceeded 20% (ratio of roof to ground) over large areas. If, for instance, the buildings were three or four decker tenement houses the potential would be increased; if they were old and poorly maintained, the problem would become even more critical. A similar map prepared today would probably show only minor changes in the overall picture. Recent redevelopment projects and urban renewal have converted some of the potentially bad areas to a tolerable level of fire susceptibility. New access highways and freeways have provided some relief from the large continuous blocks of urban fuels but large areas of critical fuels remain.

2/ Report Memo on meetings with National Fire Protection Association, by J. H. Dieterich, Oct. 22, 1964

An article in the NFPA Quarterly emphasizes the conflagration threat that exists in the South End and Roxbury Sections of the city[3/]. Since 1958 when the article was written, much successful redevelopment work has been accomplished on a city-wide basis, and work is continuing in nearly all parts of the city. Urban renewal is a step toward fuel conversion projects that will eventually reduce the chances of conflagrations. However, in the meantime, the Boston Fire Department must continue to fight these difficult fires where spacing, construction, and exposure of the buildings are so important. (Fig. 2) They have been successful in handling the fires in these difficult urban fuel types because they have recognized the conflagration potential and have been able to adapt their suppression tactics to each individual situation.

GENERAL ASSUMPTIONS

The following assumptions were made to help project these fires into conditions that might prevail during a nuclear attack:

1. Using actual weather conditions; consider each fire individually and assess the immediate fire threat that would result if only one hour of effective firefighting were possible before critical levels of radioactive fallout arrived. With mutual aid; and without mutual aid.

3/ Boston's Blighted Boroughs, by B. M. Hermes, NFPA Quarterly, Jul. 1958.

Figure 2. Urban fuels such as this tenement complex makes firefighting difficult and increases the chances of a conflagration.

2. Assess the immediate threat if the four fires had occurred simultaneously and there was only one hour of effective firefighting time available before fallout arrives, with mutual aid; without mutual aid.

3. Assume available shelter spaces are occupied when the fires occur.

4. Assume that the fire services are in a regular state of readiness and have not called in off-duty firemen.

STUDY FIRES

Bellflower Street Fire, May 22, 1964[4/]

General: This fire occurred in a congested Boston neighborhood made up mostly of well-kept, three-story, wood frame tenements. (Fig. 3) The streets are narrow and the houses are spaced closely together causing serious exposure problems. Starting at 1:38 pm on the wooden back porch of a second-story unit, the fire spread quickly to involve adjacent buildings.

Below normal rainfall had been experienced for about a month prior to the fire, and on the day of the fire, the wind was 27 mph from the southwest with gusts up to 39 mph; the temperature was 76° ; the relative humidity 37% (dry); and the sky was overcast.

4/ Dwelling Conflagration, Boston, Mass. - NFPA Quarterly Oct. 1964

Figure 3. Flames Sweep South Boston Tenements
Air view on May 22, 1964, showing flames and smoke from fire sweeping through wooden homes in crowded section of South Boston.

The fire was controlled at 4:45 pm, 3 hours 15 minutes after it started. There were a total of 70 fire and rescue companies used on the fire, 28 of which were mutual aid units from nearby communities[5/].

The official report on the fire prepared by the Boston Fire Department is on file in the NFCS Library[6/].

Shelters: Figure 4 is a map of the Boston area where the Bellflower Street Fire occurred. The fire location is indicated on the map and the Standard Location's (SL's) are outlined that form the basis for summarizing Civil Defense shelter facilities and population in the area. Table 1 summarizes the number of facilities, licensed shelter spaces, and population for both day and night. Also shown are the shelter spaces needed, or in excess, during the day and night.

5/ Boston's "Three-Decker" Fire, NFPA Fireman, Jul. 1964

6/ Official Report of the Bellflower Street Fire, by J. E. Clougherty, Boston Fire Department, May 22, 1964

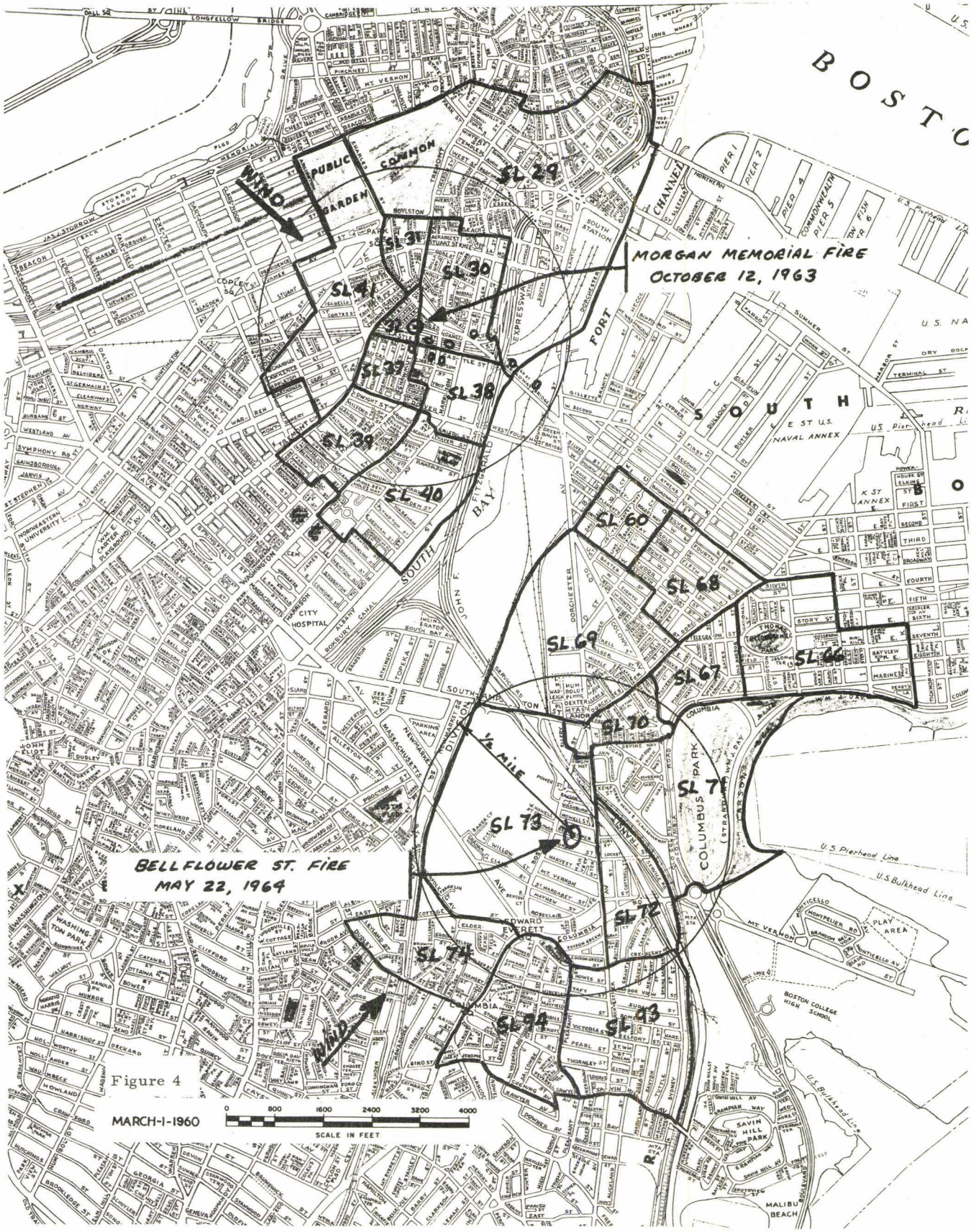
MORGAN MEMORIAL FIRE
OCTOBER 12, 1963
BELLFLOWER ST. FIRE
MAY 22, 1964
WIND
SL 29
SL 31
SL 30
SL 41
SL 37
SL 38
SL 39
SL 40
SL 60
SL 68
SL 69
SL 66
SL 67
SL 70
SL 73
SL 71
SL 72
SL 74
SL 94
SL 93
½ MILE
MARCH-1-1960
0 800 1600 2400 3200 4000
SCALE IN FEET

Figure 4

Table 1

Population and Shelter Space Summary *

(Bellflower Street Fire)

SL No.	No. Facilities	Licensed Spaces	DAYTIME Population	DAYTIME Shelter Balance	NIGHTTIME Population	NIGHTTIME Shelter Balance
73	1	168	5,332	5,164-	6,505	6,337-
70	0	0	1,508	1,508-	1,298	1,298-
71	11	968	3,189	2,221-	2,898	1,930-
60	27	4,061	3,405	656+	3,727	334+
68	4	2,113	5,549	3,436-	3,296	1,183-
69	2	3,962	2,164	1,798+	851	3,111+
67	21	3,015	3,745	730-	4,470	1,455-
66	4	2,364	6,274	3,910-	6,312	3,948-
74	1	1,430	2,983	1,553-	3,311	1,881-
93	1	155	5,702	5,547-	6,422	6,267-
94	2	520	4,263	3,743-	3,679	3,159-
72	0	0	1,630	1,630-	1,529	1,529-
Totals	74	18,756	45,744	26,988-	44,289	25,542-

* A Shelter Assignment and Utilization Plan for Boston, Mass. Dec. 31, 1963. Boston Office of Civil Defense.

The summary shows that there are 74 facilities within the Standard Location's indicated on the map having licensed shelter spaces for 18,756 people. The total daytime population is 45,744 making a deficiency of 26,988 available shelter spaces. The situation is nearly as bad at night when there is a shortage of shelter spaces totalling 25,542.

A sample of the designated fallout shelters in this area were visited to determine the relative degree of fire vulnerability. The most effective shelters visited appeared to be in a public housing area on Burke Street and Carmody Court. These were three-story brick buildings with fire-resistant roofing. Although there were wood frame windows, the yards were clear and there was good spacing between buildings and across streets. Two schools were checked for external fire vulnerability. Because of construction and exposure it was evident that both would be extremely difficult to defend if fire were moving into the area.

Fire Threat: Assuming that only one hour of fire suppression action would have been possible prior to the arrival of radioactive fallout, it appears likely that all the shelter spaces in the Standard Location's located downwind and laterally from the point of fire origin would have been exposed to a spreading fire. Upwind, the fire would have spread more slowly and radiation would probably have caused the fire to spread across the narrow streets into the wind. Major streets or freeways would have been effective in stopping the fire as it spread into the wind.

It was the considered opinion of the local fire services that, had only one-hour been available to extinguish this fire occurring from a single ignition, control would not have been possible and the fire would have jumped the major freeway indicated on the map and spread on toward the NW.

Conclusions:

a. Prompt action on the part of citizens might have prevented this fire. A bucket of water would likely have extinguished the fire in the very early stages.

b. Multiple ignitions in this area would call for prompt evacuation of all citizens, because if only two or three fires were permitted to develop, the entire community would be threatened.

c. The 600-foot wide J. F. Fitzgerald Expressway would not have made an adequate firebreak ahead of the fire if the fire had been permitted to burn with only limited control action.

Morgan Memorial Goodwill Industries Fire, October 12, 1963

General: This fire occurred at 11:37 am in a group of vacated buildings being prepared for demolition to make way for a new expressway[7/]. Strong NW winds and low humidity caused the fire to develop so rapidly that one of the multi-storied brick wood-joisted buildings was completely involved when the first fire alarm arrived. Within 5 minutes five alarms had been sounded to call in 19 engine companies, 5 ladder companies, and the rescue squad. Within 10 minutes from the time the fire started it was evident that spot fires would develop as a result of wind-borne brands and additional equipment was dispatched to meet this situation. Spot fires started in at least five large buildings, in railroad ties in a depressed railroad right-of-way and in two abandoned warves nearly four blocks away.

7/ Simultaneous Boston Fires, NFPA Quarterly, Apr. 1964.

Between 11:37 am and 5:54 pm nearly every Boston Fire Company was involved in responding to this fire and 69 additional non-related routine fires and emergency requests.

Shelters: Refer again to Figure 4, a map of the downtown Boston area showing the location of the fire and associated spot fires. Standard Location's are also indicated by number so that the reader can identify shelter space availability from Table 2. A review of Table 2 indicates that there are 211 shelter facilities available in the indicated SL's having licensed shelter spaces for 348,764 people. The daytime, or working population in this area, totals 233,350 leaving a surplus of 115,414 shelter spaces during daytime working hours and a 333,002 surplus at night. There are ample shelter spaces in SL No. 29 alone to provide some measure of protection for the entire daytime population within the indicated SL's. This might suggest that, if possible, people from nearby SL's, where shelter spaces are inadequate, should attempt to move into the downtown area to reach shelter. However, if an attack on the city's center were expected, such a move might not be for the best.

Table 2

Population and Shelter Space Summary *

(Morgan Memorial Goodwill Industries Fire)

SL No.	No. Facilities	Licensed Spaces	DAYTIME Population	DAYTIME Shelter Balance	NIGHTTIME Population	NIGHTTIME Shelter Balance
41	17	36,470	26,900	9,570+	3,815	32,655+
31	15	22,101	9,800	12,301+	280	21,821+
30	19	16,393	25,100	8,707-	2,515	13,878+
37	0	0	2,550	2,550-	1,934	1,934-
38	1	51	3,200	3,149-	329	278-
29	150	270,509	151,250	119,259+	700	269,809+
32	1	905	3,150	2,245-	333	572+
39	0	0	5,500	5,500-	2,928	2,928-
40	8	2,335	5,900	3,565-	2,928	593-
Totals	211	348,764	233,350	115,414+	15,762	333,002+

* A Shelter Assignment and Utilization Plan for Boston, Mass. Dec. 31, 1963. Boston Office of Civil Defense.

The shelter facilities in this area are located for the most part in large office buildings, commercial establishments, and in the subway system. Some of these buildings are undoubtedly more vulnerable to fire than others, but it is safe to assume that fires could not be permitted to burn in downtown Boston without posing a serious threat to other buildings in the area. We were unable to determine what proportion of the available shelter spaces listed in Table 2 might be located in the Boston Subway System. These spaces would provide some of the safest locations, provided adequate ventilation was maintained.

Fire Threat: Boston fire service personnel stated that control of this fire within one hour would have been impossible. Assuming the one-hour time limit on suppression action, it was evident a number of shelter spaces downwind would be immediately threatened by fire, and eventually the build-up area in SL No. 29 would also be threatened by the fire backing into the wind after control action had to be terminated because of fallout. The large concentration of shelter spaces in SL No. 29 are located laterially or upwind from the ignition point and spread to that area would have been relatively slow unless there would have been a shift in wind direction.

The fire spotted downwind to the channel nearly four blocks away to ignite an old warf. If the fire had been permitted to burn, it might have spread on across the Fort Point Channel to threaten the entire South Boston area.

Conclusions:

a. With the weather conditions prevailing at the time, it would have been impossible to completely rely on expressways or narrow bodies of water to halt the spread of the fire.

b. Even with most of the shelter spaces located up-wind or laterially from the fire origin, the character of the fire indicated that it would have eventually threatened the concentrated shelter areas - probably during the period when fallout would be most critical.

Codman Square Fire, October 12, 1963[7/]

General: The Morgan Memorial Fire, just described, had been burning about 2 hours and 40 minutes when this alarm was sounded. This fire originated in a store approximately 10 miles from the Morgan Memorial Fire and was controlled in about 3 hours and 40 minutes. Three large, three-story tenement houses eventually became involved. By itself, this was not considered a difficult fire, but because of the other current fire activity in the city a problem did develop. Many of the mutual aid companies were called in to report directly to the fires in progress rather than being used to cover vacant fire stations.

7/ Simultaneous Boston Fires, NFPA Quarterly, April 1964

Boston has a long history of effective mutual aid arrangements between the various cities and towns in the greater Boston area[8/]. The mutual aid response on October 12th to help control the going fires and provide support for the units in action increased the size of the Boston Fire Department by one third.

Shelters: Figure 5 is a map of the Codman Square area in the Dorchester Sector of Boston where the fire occurred. Standard Location's are indicated by number, and the fallout shelter summary for the area is indicated in Table 3. Only 10 shelter facilities having a total of 5,478 licensed spaces were available in this area when the survey was made in 1963. This left a shelter space deficit of 33,242 in the daytime and 36,609 spaces at night. Obviously, these people would need to seek shelter in other areas if they expected to find fallout protection.

8/ The Boston Fire Department, by W. Y. Kimball, NFPA Fireman, Aug. 1952

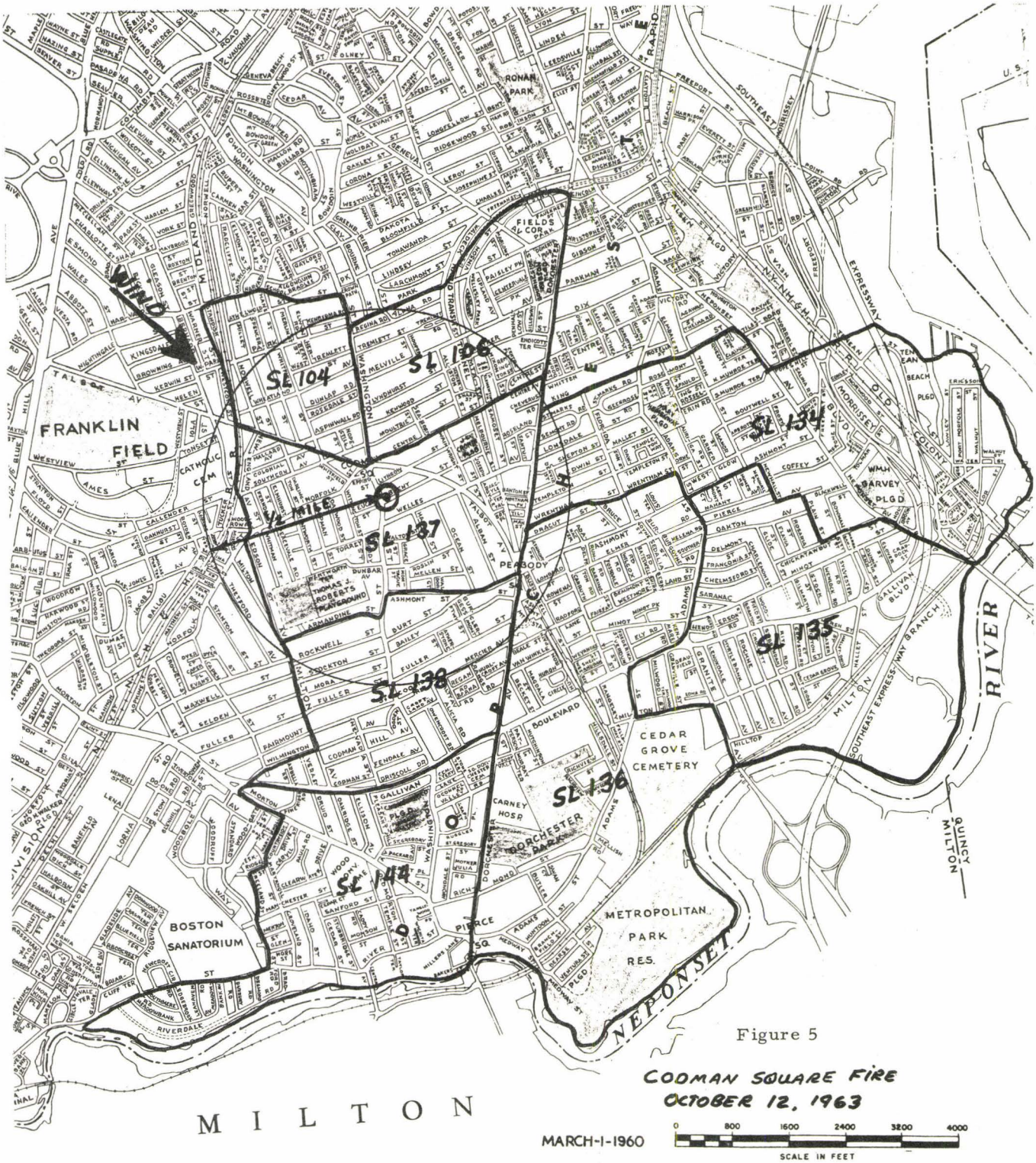

Figure 5

COOMAN SQUARE FIRE
OCTOBER 12, 1963

Table 3

Population and Shelter Space Summary *

(Codman Square Fire)

SL No.	No. Facilities	Licensed Spaces	DAYTIME Population	DAYTIME Shelter Balance	NIGHTTIME Population	NIGHTTIME Shelter Balance
137	4	1,247	7,509	6,262-	7,632	6,385-
104	1	191	4,745	4,554-	6,038	5,847-
106	1	116	4,262	4,146-	4,342	4,226-
138	1	248	4,539	4,291-	5,518	5,270-
134	1	158	10,065	9,907-	9,389	9,231-
136	2	3,518	7,600	4,082-	9,168	5,650-
Totals	10	5,478	38,720	33,242-	42,087	36,609-

* A Shelter Assignment and Utilization Plan for Boston, Mass. Dec. 31, 1963. Boston Office of Civil Defense.

The fallout shelter facilities in this area were not specifically visited as they were for the two fires previously discussed but again, as in the Bellflower Street region of Dorchester the shelter facilities were located primarily in schools and public buildings. Because of the construction of the shelter buildings and exposure of the surrounding residential areas, most of the shelter spaces appeared to be vulnerable to fire.

Fire Threat: Boston Fire Service personnel stated that of the four study fires, this fire would have come the closest to being controlled within the simulated one-hour allotted time. Even though control was not achieved for nearly four hours, they felt that enough effective work might have been done in one hour to prevent the fire from spreading. They felt also that if there had been no other fires burning in the city, control would have been achieved without mutual aid.

The population in the 6 Standard Location's shown in Figure 5 is approximately 40,000, and shelter spaces are available for only about 13% of the population. Because of the character of the shelter facilities, most of these available spaces would be threatened if fires were burning uncontrolled in the area.

This means then, that if fires were expected in the area, the people in the threatened shelters should be removed to another area; and a mass evacuation operation would be necessary to protect the remainder of the population that would be threatened by fallout.

With the NW wind prevailing there are no major breaks ahead of this fire that could be expected to stop the spread before the fire reached the park areas and expressways along the Neponset River. The river is about 1 - 1 1/2 miles from where the fire started and would provide the best available natural break to stop the fire.

Conclusions:

a. Even with adequate warning the combination threat of fallout and fire in this area might indicate the need for immediate, total evacuation.

b. Multiple ignitions in this area on a bad fire day would make one-hour control difficult, if not impossible, for all available regular and mutual aid fire forces.

c. In areas such as this where there is a heavy build-up of urban fuels and inadequate natural barriers, the threat from fire might make full use of fallout shelter spaces impractical.

Charlestown Fire, May 10, 1962[9/]

General: This fire started at about 4:00 pm under a loading platform in the freight yards of the Boston and Maine Railroad. Within five minutes the fire had spread to the first of several potato storage sheds that were eventually to become involved. Located adjacent to the storage sheds, in addition to several residences, were 31 freight cars, approximately 25 tractor-trailer units, and a four-story brick warehouse used to store cooking fats and baking supplies.

The weather had been dry for several days preceding the fire. On the day of the fire the humidity was low and the wind was from the NW at 22-38 mph. The wind was blowing nearly parallel to the railroad siding and down the line of storage sheds.

The railroad yards are slightly recessed below the general level of Lynde Street which paralleled the tracks to the north. The back yards and porches of several dwellings facing on Washington Street were exposed to the developing heat. In a short time several of these dwellings became

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9/ The Potato Sheds Fire, Official Report on Charlestown Fire of May 10, 1962. Boston Fire Department

involved. If fire had continued to spread from these buildings it would have threatened a large portion of southeast Charlestown.

The fire eventually burned nearly 2,000 feet of storage sheds, the four-story brick warehouse, several freight cars, and parts of several dwellings on Lynde and Washington streets. The responding units were handicapped from the beginning by the rush-hour traffic that filled the main routes leading to the fire and moved even more slowly to get a better look at the fire area.

Approximately 480 men from the Boston Fire Department, mutual aid cities and towns, Boston Navy Yard, Bedford Air Force and Civil Defense worked on this fire before it was declared out on the following day at about 5:00 pm. Inadequate water supply, high winds, inaccessibility, and exposure of nearby structures all contributed to difficulty of control.

Shelters: Figure 6 is a map of the Charlestown area showing where the fire occurred and the Standard Location's for summarizing shelter spaces. Table 4 lists 14 facilities having a total of 5104 licensed shelter spaces. This borough, although not as heavily populated, has much the same problem as the Dorchester and South End areas concerning shelter space availability and vulnerability of the existing shelter facilities.

We looked at several representative shelter facilities in the Charlestown area and found the majority of the spaces were in SL No. 16 in public housing projects owned by the city of Boston. The buildings are mostly three-story brick with built-up roofs and either metal casement or wood frame windows. Yards and streets provide some measure of protection from a spreading fire, and it might be possible for fire guards to protect these buildings from within to prevent fire from threatening the basement shelters. There was a school building with designated shelter spaces that would have been difficult to defend from fire, but a YMCA building located away from other buildings might afford some degree of protection from fire.

EVERETT
MYSTIC RIVER
ISLAND END R.
CHARLESTOWN
CHELSEA
LITTLE MYSTIC CHANNEL
MYSTIC PIER No. 1
MYSTIC WHARF
U.S. Pierhead Line
MALDEN BRIDGE
M.T.A. BRIDGE
MYSTIC RIVER BRIDGE
ARLINGTON BRIDGE
BOSTON INNER HARBOR
U.S. NAVY YARD
WIND
SL 19
SL 21
SL 22
SL 15
1/2 MILE
CHARLESTOWN FIRE
MAY 10, 1962
MARCH-1-1960
0 800 1600 2400 3200 4000
LE IN FEET
RUTHERFORD
PRISON POINT BRIDGE
CHARLES RIVER DAM
LECHMERE CANAL
(NORTHERN ARTERY)
MASSACHUSETTS GENERAL HOSPITAL
CENTRAL SQ.
BROADWAY
BEACON ST
PEARL ST
ARLINGTON AV
MAPLE ST
SPRUCE ST
4TH ST
9TH ST
CONDOR ST
FALCON ST
W. EAGLE ST
E. EAGLE ST
WHITE ST
TRENTON ST
LEXINGTON ST
PRINCE ST
SARATOGA ST
BENNINGTON ST
MORRIS ST
PUTNAM ST
BORDER ST
MERIDIAN ST
BREMEN ST
PARIS ST
LUBEC ST
GENEVA AV
VENICE ST
EVERETT ST
MAVERICK SQ.
SUMMER ST
MARGINAL ST
AIRPORT
AUDUBON STA.
ATHLETIC FI
BOSTON & ALBANY
AM. LEGION PLAYGROUND
CHARLESBANK PLAYGROUNDS
NASHUA ST
RAILROAD AV
TERMINAL ST
ROLAND ST
MYSTIC AV
ARLINGTON AV
BUNKER HILL MONUMENT

Figure 6

Table 4

Population and Shelter Space Summary *

(Charlestown Fire)

SL No.	No. Facilities	Licensed Spaces	DAYTIME Population	DAYTIME Shelter Balance	NIGHTTIME Population	NIGHTTIME Shelter Balance
21	0	0	2,000	2,000-	2,833	2,833-
22	2	524	2,000	1,476-	2,383	1,859-
16	8	4,236	3,000	1,236+	4,187	49+
15	4	344	1,500	1,156-	2,518	2,174-
Totals	14	5,104	8,500	3,396-	11,921	6,817-

* A Shelter Assignment and Utilization Plan for Boston, Mass. Boston Office of Civil Defense. Dec. 31, 1963

Fire Threat: This is another area of critical urban fuels in Metropolitan Boston where fires must be controlled when they are small because of the potential for conflagration development.

It would have been impossible to control this fire within the one-hour allotted time, and without any additional control action, the fire would likely have spread with the wind through southeast Charlestown and into the U. S. Navy Yard. Moving laterally by radiation, the fire would have threatened virtually all of Charlestown north of the Mystic River. Boston Inner Harbor and the Charles River should have provided an adequate break on the south and southeast.

The overall character of Charlestown is not likely to change to any large extent over the next few years. Some urban renewal may occur as it has in other areas, but unless major changes are made the conflagration threat will remain.

Table 4

Population and Shelter Space Summary *

(Charlestown Fire)

SL No.	No. Facilities	Licensed Spaces	DAYTIME Population	DAYTIME Shelter Balance	NIGHTTIME Population	NIGHTTIME Shelter Balance
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The overall character of Charlestown is not likely to change to any large extent over the next few years. Some urban renewal may occur as it has in other areas, but unless major changes are made the conflagration threat will remain.

Conclusions:

a. Even with an immediate response by the fire services, this single ignition developed sufficiently to threaten most of Charlestown.

b. Multiple ignitions in this area, under these weather conditions, would probably result in such rapid development of mass fires that evacuation would be difficult.

c. Charlestown, like Dorchester and Roxbury, is a potential conflagration area. If small fires are not extinguished or if primary ignitions are too numerous to be effectively controlled by the fire services and the citizens, virtually the entire community would be threatened by fire.

Simultaneous Occurrence of Study Fires

Under "General Assumptions" stated earlier we proposed to assess the immediate threat if the four fires had occurred simultaneously; and there was only one hour of effective firefighting time available before fallout arrives.

It seems evident after reading the previous discussions of the individual fires that, had these four fires occurred at nearly the same time and under any of the stated weather conditions, control within one hour would have been unlikely. Even with the excellent mutual aid arrangements in effect in the Boston area, the combined efforts would probably not have been successful in controlling the fires in the short time available. The consequences of four such uncontrolled fires in the Boston Metropolitan area would be (1) the destruction by fire of vast areas of industrial and residential developments, and (2) to threaten fallout shelters in a large part of the city.

OBSERVATIONS

1. The effects that nuclear fallout would have on firefighting capabilities is not recognized nor understood by the public or by the fire services.

2. The Boston Fire Service personnel interviewed were reluctant to recognize they might need to seek shelter after an hour of fighting fires. They maintained that in accordance with previous training and policy they would probably continue to fight the fire in the face of fallout.

3. The theory that nuclear weapons could cause initial ignitions within even a limited radius out from ground zero is not fully accepted.

4. There seems to be a need for a better understanding of (a) the effects of nuclear fallout, and (b) the fire problem that might result from an enemy attack.

5. If fallout shelters were in the path of a fire that could not be controlled within a one-hour period, the fire services felt that the shelters should be evacuated, but that they should not be the ones to do the job because they would be busy with the fires. Evacuation would be either by police or independent action.

6. Fallout shelter distribution is a critical problem in a city like Boston. There appears to be adequate shelter spaces (not necessarily stocked) for the daytime, downtown, working population. The problem would be to provide for complete utilization of the available spaces.

7. Critical fire weather appears to be associated with many of the large urban fires in Metropolitan Boston. The structural characteristics of the city seems to encourage a response to fire weather changes in much the same way as wildland fuels.

8. Chief Clougherty believes that even the most intensive of fire prevention education programs cannot guarantee a continued reduction in the number of fires. He emphasized the need for increased fire protection through research to develop methods, materials, and procedures to make it increasingly more difficult for the public to cause fires accidentally or intentionally.

9. Citizen action could be effective in extinguishment of small ignitions immediately after a nuclear attack and before taking shelter from fallout. To be effective, education and training would be required.

10. A thermal flash in some areas of Boston could cause so many fires that only selective control action would be feasible.

11. Current fire control effort in Boston is geared to an almost unlimited water supply. No attempt was made to assess the situation if only limited water supplies were available.

GENERAL CONCLUSIONS

1. Many of the shelter buildings could not be protected adequately from within because of building construction and exposure to nearby fire susceptible buildings.

2. If shelter buildings are spaced and constructed so that they offer some resistance to fire, effective fire guard activity would be possible; heavy fallout and fire susceptible buildings would make fire guard activity less effective.

3. Fallout shelters in office buildings and schools in the Boston area do not generally provide adequate protection from a spreading fire. The underground shelters (subway system, etc.) offer better protection from fire but adequate ventilation must be insured.

4. Structural characteristics, building spacing, and materials used in siding, roofing, and general construction are major factors in considering whether or not an area would be defensible if multiple ignitions occurred. Building exteriors have a pronounced effect on fire spread and development.

5. Structural fires spread relatively slowly into the wind so that freeways or even wide streets may halt the spread of fire to a large extent.

6. Some control effort is needed to stop an urban fire moving with the wind except for all but the very widest of fire breaks. Expressways may be inadequate due to the transport of fire brands, particularly if the fire reaches the break unchecked.

7. If multiple ignitions occurred in any of the boroughs where the study fires were located, the entire communities would be threatened - in fact, the area probably would have to be "written-off".

8. If many fires start simultaneously the fire service personnel indicated that they would attempt selective control and sacrifice some areas that could not be defended.

9. Fallout shelters should be risk-rated for fire vulnerability so pre-emergency planning could identify which shelters might be defended from fire and which would have to be evacuated.

10. In pre-emergency planning, the Boston Fire Service emphasized the need to expand on the existing organization to meet emergencies of unpredictable proportions.

11. The successful use of mobile hand lines, rather than stationary master streams, on some fast spreading Boston fires may indicate a need to adapt this tactic to handling multiple small fires in other areas.

RECOMMENDATIONS

1. Education in the effects of nuclear weapons, particularly fallout, is needed for both public officials and the general public. Educational programs should be designed to meet expected occurrences, i.e. the fire problem resulting from nuclear attack on the city of Boston, in addition to blast and fallout.

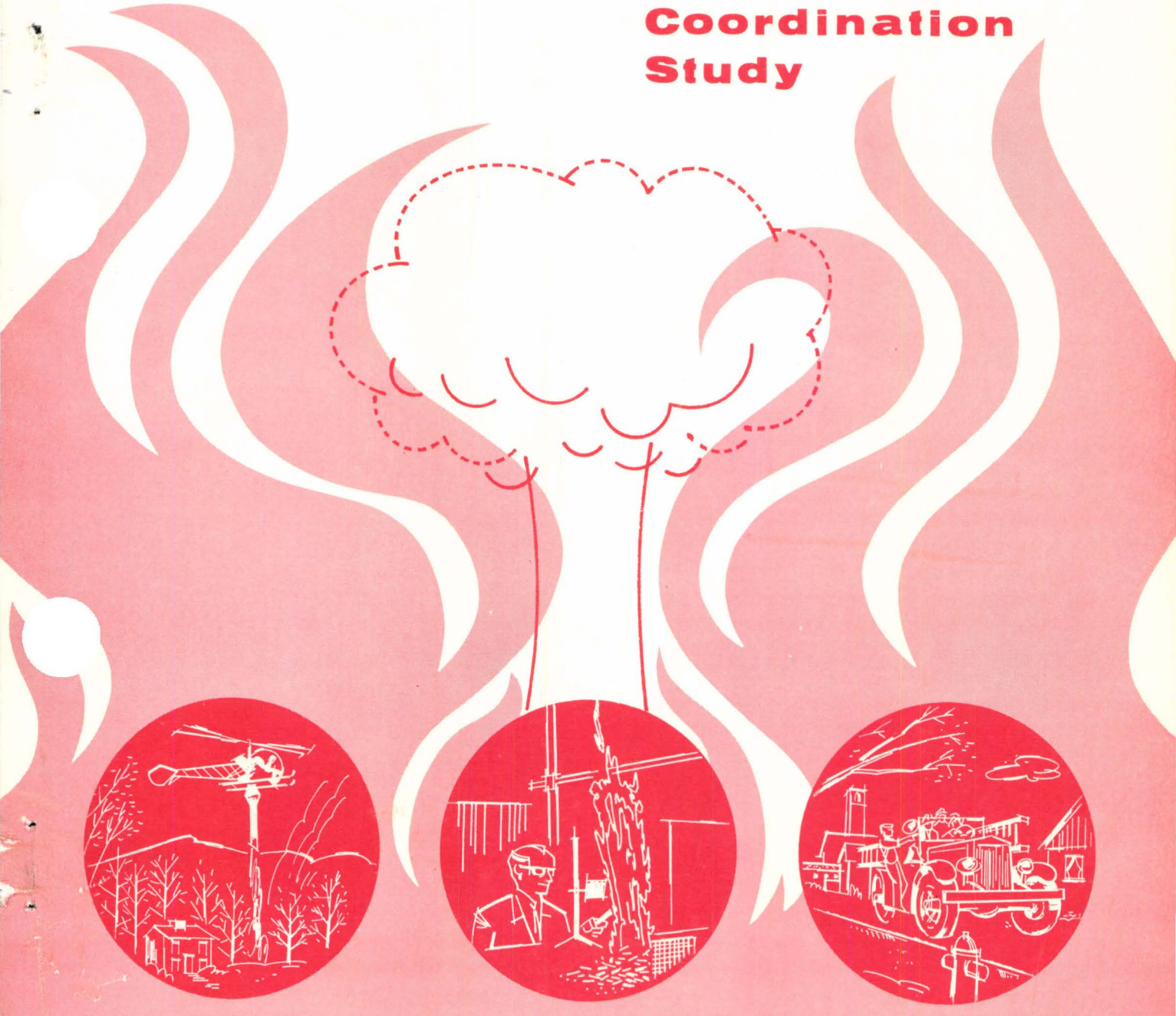
2. The threat of fire resulting from a nuclear attack on Boston emphasizes the need for developing a system of rating fallout shelters for fire vulnerability. This fire risk rating for each shelter facility would permit early recognition of hazardous shelter spaces.

3. Continue to develop a decentralized system of fallout shelters that provide for maximum fallout and fire protection both from without and within. This shelter capacity is needed in the vicinity of peoples' homes and would mean utilizing more residences or other buildings having a relatively low shelter capacity.

4. Cities and communities should develop a plan that clearly defines the responsibilities for evacuation and rescue for various levels of emergencies - including nuclear attack.

California
COYOTE FIRE

National Fire Coordination Study



U.S. DEPARTMENT OF AGRICULTURE/FOREST SERVICE/DIVISION OF FIRE CONTROL

FIRE STUDY REPORT

COYOTE FIRE

LOS PADRES NATIONAL FOREST

CALIFORNIA

1964

ANALYSIS AND REPORT

by

Theodore G. Storey, U. S. Forest Service

Cities of Santa Barbara and Montecito, Santa Barbara County, California; State of California, Los Padres National Forest and Region 5, U. S. Forest Service Cooperating.

June 1965

Reviewed by

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Prepared by the U. S. Department of Agriculture, Forest Service, Division of Fire Control, National Fire Coordination Study, Washington, D. C. for the Office of Civil Defense under contract OCD-PS-64-229.

FIRE STUDY REPORT

COYOTE FIRE

Santa Barbara, California

1964

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I. INTRODUCTION

Between September 22 and October 1, 1964 the Coyote Fire seriously threatened the city of Santa Barbara and adjacent communities situated along the coast of Southern California. Approximately 67,000 acres were burned including 188 structures destroyed or damaged. One man was burned to death, 226 were injured, and $22,000,000 in damages were sustained with suppression costs totalling $2,700,000.

National Fire Coordination Study OCD Project 229, objectives call for specific investigation of selected fires, both current and past, to relate methods and equipment used on large fires during peacetime to potential fire problems associated with nuclear attack. The Coyote Fire was chosen for study because it represents a situation in which several fire suppression agencies under one G.H.Q. were involved in control of a large fire burning both urban and rural areas. (see Appendixes A & B). Urban areas were evacuated ahead of the fire, and were purposely backfired to save larger groups of structures. Air attack was concentrated to save particular structures and trapped persons, and helicopters were used to restage personnel to other areas and transport injured firefighters. Other contemporary fires burning at approximately the same time, including the 71,000 acre Santa Rosa fires to the north, made the situation even more critical from the standpoint of available firefighting resources.

II. FIRE DESCRIPTION

LOCATION

The city of Santa Barbara is situated along the Pacific Ocean in the southeast corner of Santa Barbara County in Southern California. In this vicinity the coastline runs in a due east-west direction. Directly behind the city and paralleling the coast rise the Santa Ynez range of mountains. These mountains are steep and rugged with an average elevation of about 3,000 feet and with one peak rising to an elevation of 4,000 feet. Beyond the Santa Ynez divide is the Santa Ynez River drainage which slopes to the west. The Coyote Fire burned both sides of the mountain range for a distance of 21 miles in an east-west direction and 11 miles north to south. (Figure 1)

SIZE AND DAMAGE

Approximately 67,000 acres were burned on the Coyote Fire. Land ownership of the burned area is as follows: (see Appendix C, Official Fire Report)

Ownership	Acres Burned
National Forest land	46,000
Private and other land inside the National Forest Boundary	17,000
Private and other land outside National Forest Boundary	4,000
TOTAL	67,000

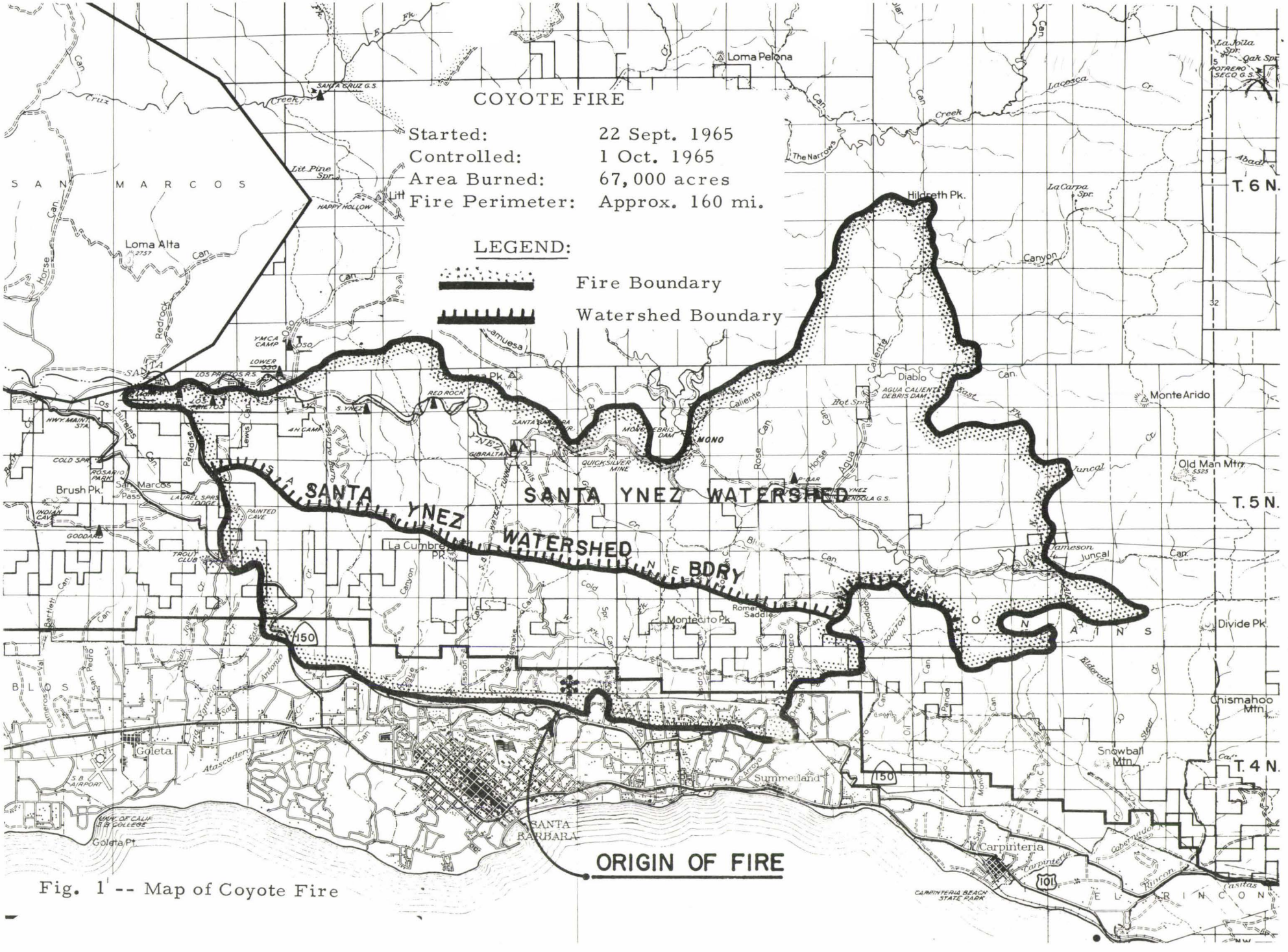


Fig. 1 -- Map of Coyote Fire

Santa Barbara (population 60,000) and the adjacent community of Montecito suffered extensive losses and damage from the fire. Neither downtown area was destroyed, but fire did burn many residences within the city limits and the county just outside. Total damages of approximately $22,000,000 are broken down as follows:

Damage	Amount
To Improvements	$ 3,000,000
To Watershed	15,710,000
Post-Fire Rehabilitation Costs	3,000,000
TOTAL	$ 21,710,000

Improvements damaged included 188 structures (destroyed or damaged), public utility lines, power poles, and roads. The figures do not include indirect losses such as payroll losses, personal property losses, and personal expenses during the evacuation period.

Fire suppression costs were $2,700,000 including $2,500,000 to the Forest Service and $200,000 to other fire agencies and contributions from cooperators.

CASUALTIES

The Coyote Fire was very costly in terms of accidents both to personnel and equipment. There were approximately 227 accidents involving firefighting personnel during the course of the fire. A major blowup, on Thursday, September 24, resulted in one burn fatality and 50 burn cases in two different accidents within a period of approximately one-half hour.

There were no flying accidents among the 15 air tankers and 19 helicopters on the fire.

FUELS, WEATHER, AND TOPOGRAPHY

All three of these factors contributed to the extreme behavior and suppression difficulties experienced on the Coyote Fire.

1. Fuels: The natural fuels in the fire area are predominantly light to heavy stands of mixed brush or chaparral with grass and scattered non-commercial scrub oak trees. (Figure 2) A portion of the Coyote Fire was in the old Refugio burn of 1953. Brush sprouting and regrowth is rapid in the area following fire so much of the fuel was at or near maximum volume for the site at the time of the fire.

   In September the Southern California wildland fuels usually are at their maximum dryness. Grass is dead and cured and green fuels are at minimum moisture content. Samples of living chaparral taken on September 25 in the fire area showed chamise to have a moisture content of about 60 percent and scrub oak about 79 percent. These moisture contents are near minimum for living fuels of these species, and at this moisture level living fuels contribute significantly to the intensity of a fire.

Fig. 2 -- Brush and grass fuel type on Coyote Fire.

Natural fuel development during the 1964 fire season in Southern California was particularly heavy. Early winter rains started the brush and grass growing earlier than usual. During February and March, however, dry Santa Ana winds desiccated the brush and killed much of the grass growth. Near normal spring rains started vegetative growth again and increased the amount of grass and other annual vegetation in the chaparral covering the mountain slopes, thus providing abundant fine fuel for ignition and rapid fire spread. The fire potential was increased by the large amount of dead material in Southern California chaparral as a result of more than 15 years of drought.

Urban fuels consisted of residences and outbuildings scattered among the brush and grass covered hills. (Figure 3) Most of the residences destroyed had inadequate clearing between house and brush so fire in the brush was readily communicated to the structure. Flying brands from burning residences intensified the fire suppression problem. Reliable observers reported wood shingles supplied some of the flying brands and wood shingle roofs readily ignited from fire brands.

Fig. 3 -- Residence located in heavy brush being threatened by Coyote Fire.

Because the roads in the area were so narrow, they provided little in the way of effective fuel breaks. There was an existing fuel-break along the Camino Cielo which follows the crest of the Santa Ynez mountains. It consisted of a cleared strip covered with grass much of which was less than 100' wide. The purpose of the break was to slow or stop a fire burning up the mountain, to provide access for suppression forces, and to provide a cleared line to backfire from in a fire emergency. This break was ineffective in stopping or materially slowing the running fire. The reasons were that portions of the break were narrower than standard and it was hit by fire rolling at full speed. The fire also spotted across the Montecito fuel-break situated above the town of Montecito shortly after origin.

2. Weather: Fire danger in the 1964 season, although not marked by extended periods of extreme fire danger, remained consistently high. The combined effect of high fire danger, a large volume of fine fuels, and a large amount of dead heavier fuels resulted in unusually fast spreading fires. Two such fires were the Dry Fire on the nearby Angeles National Forest in early July and the Cozy Dell Fire on the San Bernardino Forest in August.

The general weather pattern that led to the development of the Santa Ana wind condition under which the Coyote Fire burned has been classified as the "Great Basin High - Pacific High." 1/ In North Central California strong winds were reported in Napa, Sonoma, and Mendocino counties beginning on September 20 and reaching a peak on September 22. Several large fires started in this area during that period and seriously threatened the cities of Calistoga, Santa Rosa, and adjacent communities. 2/ A large number of structures were destroyed.

In Southern California strong Santa Ana winds began to appear early on September 22, a few hours before the start of the Coyote Fire. Humidity ranged from 10 to 15 percent. The Santa Ana began to subside on September 24, and sea breezes brought cool, moist air to much of the fire area on September 25. Extreme fire behavior persisted several days after the Santa Ana winds had stopped. Fire weather observations taken at various locations on the Coyote Fire are given in Appendix D.

1/ "Synoptic Weather Types Associated With Critical Fire Weather," by Schroeder, Mark J., et. al. PSW, 1964.

2/ "Santa Rosa Fires," by T. G. Storey, Project 229, National Fire Coordination Study, USDA, Forest Service, Division of Fire Control, 96 pp., April, 1965.

3. Topography: Topography was extremely steep and rough in most of the fire area. Access roads were mostly too narrow for fire suppression purposes and traffic congestion during initial attack was one reason that the fire escaped.

Much of the fireline off the roads was steep and inaccessible to equipment, even bulldozers, and much line had to be put in by hand. The fire suppression efforts were hampered by limited access to the fire perimeter and lack of 4-wheel drive equipment capable of traversing more of the steep terrain.

CONTROL TIME

The Coyote Fire started at 2:02 pm on September 22, 1964 and the final perimeter was reached about 4 1/2 days later at the end of the shifts on September 26. There was open line at this time but no appreciable perimeter spread occurred after this date. Hand crews and tractors continued to construct line until the perimeter had a line on it on October 1, 1964, when the fire was reported controlled. Mop-up operations continued for several days thereafter.

RATE OF SPREAD

There were reports of some extreme rates of spread for short periods during the first four days of the fire. One of the longest sustained runs occurred between 6:00 pm September 23 and 6:00 am September 24. In this 12-hour period the fire spread 10 miles at an average speed of 4/5 miles per hour. There were many cases of fires spread by flying brands. Spot fires as far as 1/4 mile ahead of the main fire front were reported in several instances. The spot fire east of Painted Cave on Wednesday night was 1 1/4 to 1 1/2 mile ahead of the main fire front.

FIRE SUPPRESSION FORCES EMPLOYED

On the peak day there were 3,437 men and 326 pieces of fire equipment on the fire distributed as follows:

Item	Forest Service	Other	Total
Men	2,837	600	3,437
Ground Tankers	94	104	198
Tractors	--	--	94
Air Tankers	--	--	15
Helicopters	--	--	19
		TOTAL	326

The equipment figures do not include the many equipment transports, buses, pickup trucks, ambulances, and other service and supply vehicles, numbering several hundred, in use on the fire.

Eight fire camps were established with two general headquarters (GHQ) located as follows:

Fire Camp	Date Established
Westmont (College)	9/22/64
La Cumbre	9/23/64
Pendola	"
Tucker's Grove	"
Polo Field (Carpinteria)	9/24/64
Los Prietos	9/25/64
Potrero Seco	9/26/64
Mono Flat	9/27/64
GHQ	
Polo Field (Carpinteria)	9/24/64
Tucker's Grove	——

The air attack base was in Goleta, approximately 12 miles airline from the fire center, with alternate bases some distance inland in case Goleta was overcast or fogged in.

Air attack used 15 tankers to drop 600,000 gallons of retardant in 723 trips. Nineteen helicopters delivered more than 600 men to and from the fireline. A few retardant drops were made from helicopters.

AGENCIES AND FIRE SERVICES

In addition to the Forest Service, the agency having primary responsibility for control, several public agencies became immediately involved in the suppression action at the start of this fire. The number of agencies increased as the situation became more complex. Strategy meetings were conducted currently to establish zones of action and responsibility among the various fire and law enforcement agencies involved in an attempt to reduce confusion and avoid omission or duplication of effort. Cooperators and the service and equipment furnished are listed below:

1. Cooperating Fire Agencies

   a. Montecito Fire District - Personnel and Tanker equipment.

   b. Santa Barbara City Fire Department - Personnel and Tanker equipment.

   c. Santa Barbara County Fire Department - Personnel, Tankers and Tractor equipment.

   d. California Division of Forestry - Personnel, Tanker equipment, a fire camp and camp crew, Liaison Staff, Air Tankers and retardants. Assisted in obtaining inmate firefighters, kitchen crews, and other manpower.

   e. Los Angeles County Fire Department - Personnel, Tanker and repair equipment, Air Tankers and retardants and sector teams.

   f. Ventura County Fire Department - Personnel, Tanker and Tractor equipment and Helicopter.

g. Kern County Fire Department - Personnel and Tanker equipment.

h. Los Angeles City Fire Department - Personnel and Tanker equipment.

i. Carpinteria-Summerland Fire District - Personnel and Tanker equipment.

j. California Disaster Office - Personnel, Tanker, Communications and repair equipment and Liaison Staff.

2. Cooperating Law Enforcement Agencies

a. Santa Barbara County Sheriff's Office - Traffic control, and roadblocks, evacuation, arson investigation, policing in fire area for looting and sightseer control, fire camp security and message relay.

b. California Highway Patrol - Traffic control and roadblocks, assisted in evacuation, escorted and assisted in moving tractor equipment and message relay.

c. Santa Barbara City Police Department - Traffic control and roadblocks, assisted in evacuation, policing in fire area and message relay.

3. Other Cooperating Agencies

a. California Department of Corrections - Organized inmate firefighting crews and camp kitchen crews.

b. National Park Service - Helicopter and crew from Sequoia National Park.

c. Federal Aviation Agency - Restricted air space over fire area, relayed messages to and from chartered aircraft, provided close cooperation and priority in air traffic control at Goleta Air Base and office space for Air Transportation Officer.

d. Weather Bureau - Mobile weather units and fire weather forecasters, and special fire weather forecasts as requested as well as current weather forecasts by shift and zone.

e. California Department of Employment - Lists of available manpower and aided in recruiting people for some "hard to fill" jobs.

f. California National Guard - Personnel, transportation equipment and use of Armory for demobilization.

g. U. S. Navy - Personnel and transportation units, tractor equipment and manpower.

h. U. S. Marine Corps - Personnel, transportation and repair equipment, camp crew and manpower.

i. U. S. Air Force - Personnel and transportation units.

j. U. S. Army - Personnel and transportation units.

k. California Division of Highways - Assisted in clearing movement of tractor equipment over highways.

1. Santa Barbara County Parks and Recreation Department - Facilities for GHQ Fire Camp at Tucker's Grove.

4. Other Cooperators

   a. Westmont College - Facilities for Fire Camp.

   b. Santa Barbara Polo Association - Facilities for Fire Camp and GHQ.

   c. Santa Barbara YMCA - Facilities for demobilization.

   d. Many other organizations, such as Churches, Fraternal groups, Schools and Colleges, the Salvation Army and Red Cross. Individuals by the hundreds gave of their time, offered food and supplied much needed encouragement.

Cooperators were too numerous to list individually, but included labor associations, contracting firms, construction companies, ambulance service, hospitals, air and ground transportation, and food and material supply sources. The North American Weather Consultants supplied some of the special weather forecasts mentioned elsewhere in this report.

Santa Barbara Labor Association and the Ventura County Citrus Association supplied organized crews of agricultural workers including Mexican Nationals, for manpower in the early stages of the fire. These men were badly needed for critical agriculture work and the Forest Service released these crews as rapidly as possible, replacing them with other manpower ordered through the Zone and Regional Dispatchers.

Overhead and crews were sent to the fire from all 17 National Forests in the California Region (R-5) and from Regions 1, 3, 4, and 6 (Montana, Utah, Oregon, Washington, Arizona, and New Mexico). The Forest Fire Laboratory of the Pacific Southwest Forest and Range Experiment Station furnished the Fire Behavior Officer and 8 assistants on the fire plus a member of the fire study team.

FIRE BEHAVIOR

The fire started on the early afternoon of September 22 on the outskirts of Montecito and Santa Barbara and burned toward the north and northeast with southwesterly thermal winds. (Figure 4) This despite the fact that there was a strong offshore gradient. The first residences were destroyed at about 3:00 p.m. At about 10:00 p.m. PDT the Santa Ana wind surfaced along the Santa Barbara front--that is, it blew downslope from the north or northeast--and carried the fire downslope into residential areas where it consumed a number of houses. This wind lasted until about 3:00 a.m. on September 23. During the rest of that night the winds along the front were light downslope drainage winds.

Until the afternoon of September 23 the fire was confined to the Santa Barbara front. During the afternoon, however, it crossed the ridge of the Santa Ynez mountains at Cold Springs saddle and slopped over into the Santa Ynez drainage. The fire ran down the north-facing

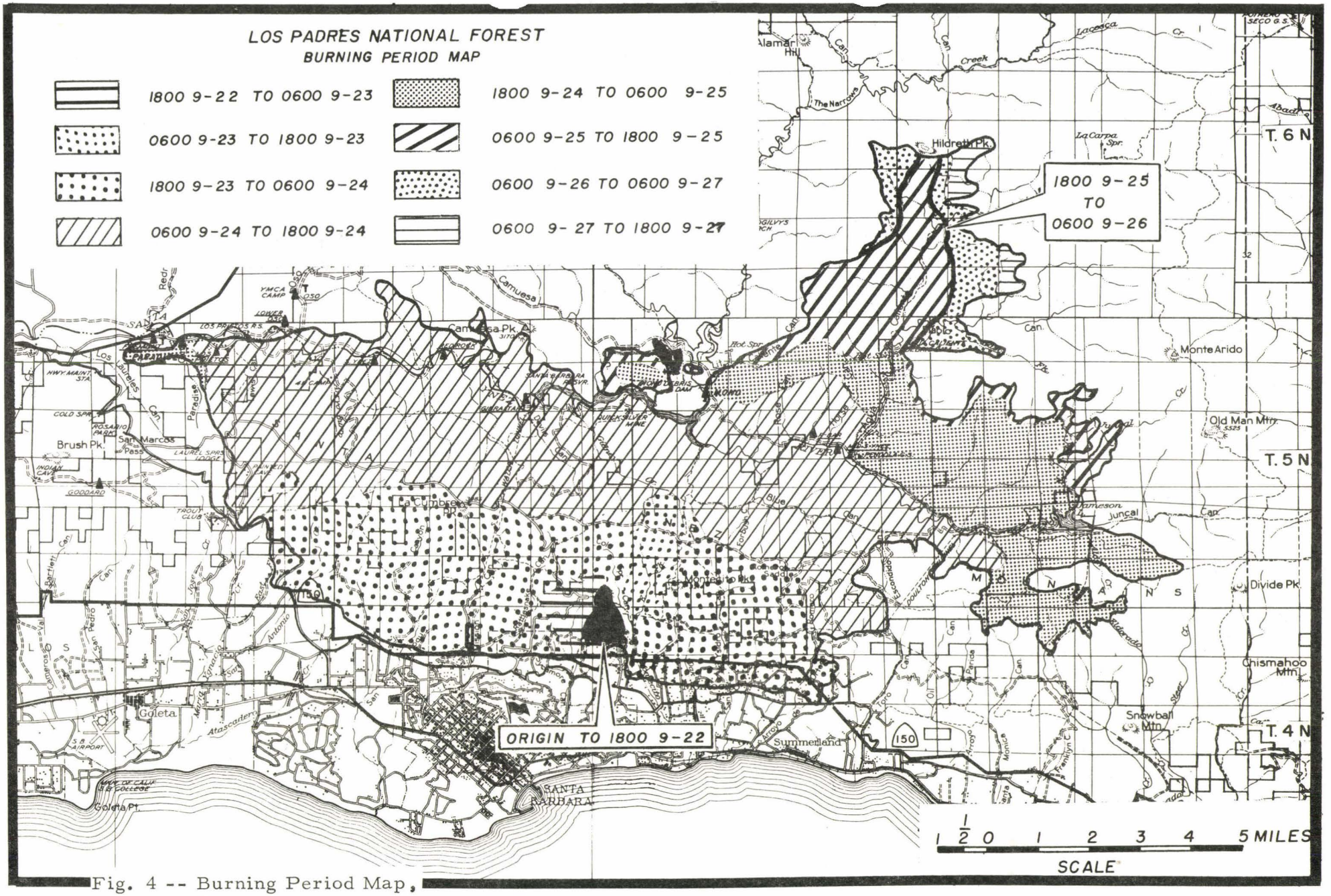


Fig. 4 -- Burning Period Map, Coyote Fire

slope after it crossed the ridge at the saddle. The layer of southwesterly winds became deep enough to carry through the saddle and become downslope winds on the north side. The winds along higher portions of the ridge did not become southerly.

During the early evening of September 23 downslope drainage winds developed along the front and temperatures dropped to the high 70's. About 7:00 p.m. strong northeasterly winds hit the ridge of the Santa Ynez mountains. Between 7:30 p.m. and 7:45 p.m. these winds surfaced along the Santa Barbara front. Temperatures went up to the high 80's and low 90's and humidities dropped to around 14 percent. For a time at Westmont College Fire Camp temperatures alternately went up and lowered 10-15 degrees in seconds as the warm, dry northeasterly wind was detected. The warm air remained at the surface and the northeasterly winds continued to blow until about 5:45 a.m. on September 24. During the nighttime period that the Santa Ana winds surfaced, the fire burned fiercely and spread again into residential areas of Santa Barbara and Montecito areas where it consumed many houses.

Early in the forenoon on September 24 onshore and upslope winds developed first at low levels, while northeasterly winds continued at higher levels. Houses in the Painted Cave area on the west side of the fire were burned in this forenoon period. The atmosphere became more unstable and favored the development of

large convection columns. It was on this day between 12:00 noon and 1:00 p.m. that a number of firefighters were burned - one fatally - in two separate accidents. One was on Cold Springs saddle, the other near Romero saddle on the watershed boundary north of Montecito.

During the night of September 24 the Santa Ana winds did not surface but remained aloft. The fire continued to spread until early morning on September 25 when warm air moved into lower elevations along the Santa Barbara front and humidities rose to 70 percent and higher. During the day moist marine air covered most of the front and began to move up the Santa Ynez drainage also. The upper part of Santa Ynez drainage and the higher elevations generally remained in dry air. Stratus clouds moved inland in late afternoon. The top was about 1,200 feet elevation.

Very little perimeter spread occurred after 12:00 p.m. September 26. The fire was declared controlled on October 1, 1964.

III. ANALYSIS

Early in the event the fire area was declared by the Governor of California to be in a "State of Disaster" under Section 1505 of the California Disaster Act. This made available to the Forest Service much additional fire suppression and rescue assistance within the framework of the Fire and Rescue Service of the State Fire Disaster Plan.

SEQUENCE OF FIRE ACTIVITY

The Coyote Fire started at approximately 2:01 p.m. PDT on September 22, 1964, on the west side of Coyote Road 1/10 of a mile below its junction with Mountain Drive Road (Fig. 1). This was beside a city street in a residential area, about 2 feet outside the city limits of Santa Barbara. The point of origin was on private land outside the official National Forest boundary, but within the contractual protection boundary. A vehicle exhaust spark falling in dry grass was the probable cause of the fire.

The following Forest Service log of early fire activity has been abbreviated, but will serve to demonstrate mobilization.

First Phase (Initial Attack)

September 22, 1964 - 1401 hrs.: Fire discovered by a local resident who immediately reported it by telephone, to the Montecito Fire District Station No. 1. Elapsed time between origin and discovery was between three and four minutes and is well within Regional objectives. The origin was blind to La Cumbre Lookout four air line miles to the northwest.

1403: Fire reported by telephone to Ranger District Clerk-Dispatcher in Santa Barbara by the Mission Canyon Fire Prevention Technician (FPT) who had monitored the Montecito Fire District radio dispatch. The Clerk-Dispatcher immediately notified Forest Dispatcher by radio. The two minute elapsed time from discovery to report meets Regional time standards.

1404: The Mt. Drive crew (3 men) with a Class I Tanker and the Mission Canyon FPT and one fire crew member with a Class III Pumper departed for the fire. They were the nearest to the fire from a travel time and distance standpoint, and were first on the scene. This response was followed closely by Santa Barbara City Fire Department with 1 engine and Montecito Fire District with 2 engines.

1404-1419: The next 15 minute dispatch, handled both by the district and forest dispatchers, included the following forces: All additional district personnel (20 men) and equipment; 3 Class I Tankers, 5 Class III Tankers, 1 Helicopter and Los Prietos Hot Shot Crew: The two Goleta Air Tankers and Lead Plane, 5 additional Air Tankers from South Zone, the preplanned assistance from all the other districts on the forest except the Monterey (they had fire problems of their own), totaling 58 men, 4 Class I Tankers, 3 Class III Tankers. In addition, Montecito Fire District dispatched 4 engines (14 men), Santa Barbara City 5 engines (20 men), Santa Barbara County Fire Department 3 tankers (12 men).

1406: Mt. Drive Crew and Mission Canyon FPT arrived at fire and began live reel and hose lay action. The fire was well established at approximately 1/2 acre, but was still confined to the west side of Coyote Road and south of Mt. Drive. The Mt. Drive Crew attempted to move around the fire and tie it back into Coyote Road. The Fire Prevention Technician moved to the head of the fire to cool it down as it burned into Coyote Road. Fuel was moderate brush with grass.

1408: Fire crowned out through a live oak tree and spotted across Coyote and Mt. Drive Roads. Mt. Drive Crew abandoned action west of Coyote Road and moved to the spots across Mt. Drive. The Mission Canyon FPT also started work on the spots.

1412: District Assistant Fire Control Officer (FCO) arrived and took charge. Fire was spreading rapidly up slope in heavy brush threatening several houses. District Fire Control Officer en route to fire ordered 50 local laborers and two dozers when Assistant FCO reported fire across Mt. Drive.

1416: Santa Barbara City Fire Department engine and 3 men arrived, started work on spots east of Coyote Road.

1418: Additional ground tankers started arriving. Forest Service forces were concentrated on fire above Mt. Drive which was now well established and had started burning the first house, adding to the spotting problems further up the slope.

1420: Air Tankers began to work on spots above Mt. Drive under direction of Lead Plane Pilot and Assistant FCO. Power transmission lines in the area precluded air tankers from pinpointing their normal attack.

1430: Fire was about 15 acres ... five acres of it burning above Mt. Drive. Roads into the area were becoming congested. Additional manpower and equipment were having difficulty in getting to the fire.

1445: District Fire Control Officer arrived and took charge.

1500: Spot above Mt. Drive was approximately 15 acres - four houses were involved and the head of the fire was now burning intensely in dense, mature brush. Flanking action was making good progress. However, it was evident that without slowing the head of the fire the flanking action would never turn the corner.

1510: Effort was made to get tankers and manpower on the Montecito fuel-break at the head of the fire and establish a "toe-hold".

1600: Fire spotted 1/4 mile over fuel-break and it was obvious that a major fire was under way and that a large fire organization would be needed to handle the situation. The Forest Fire Control Officer assumed command and regrouped forces, assigning crews to a Division Boss. Perimeter line construction started.

Had these spot fires not occurred, the Coyote fire would very likely have been controlled at around 15 acres.

Second Phase (Escape from Initial Attack)

September 22 - 1600-1700: Line completed on west flank and across the head of the fire that held until 1700 the next evening. Good progress made on line along east flank; heavy air attack assisting.

1700: Meeting between all agencies again establishing zones of responsibilities; Forest Service to handle all line action above Mt. Drive; Santa Barbara County, City, and Montecito Fire District to handle all structures and all control action below Mt. Drive.

1900: Last air tanker drop made. Good possibility for establishing control at about 300 acres.

2000: Crews making good progress; 1/2 mile of open line. Two hundred and fifty men on the line with additional forces on the way. Fire camp established at Westmont College Athletic Field.

2030: Strong down-canyon (northeast) wind began to blow breeching the west flank. Control quickly reestablished. East flank not controlled and spread continued.

September 23, 1964 - 0600: Approximately 1800 acres burned to date; still spreading.

1000: Fire spread into Cold Springs Canyon proper and toward the Camino Cielo.

1400: Fire crossed the Camino Cielo and started down into the Santa Ynez drainage. Meeting held between the Forest Service and all fire agencies to coordinate action. Force consisted of 10 air tankers, 3 helicopters, 47 tankers, 26 tractors, and 1,300 firefighters.

1800: About 1/2 of the fire perimeter was controlled and line held, this on the west and north sides. Weather forecast and fire behavior forecast favorable; only a 10 percent chance of the northeast winds coming back down to ground level that night.

1830: Another coordination meeting with the Forest Service, Fire Chiefs, Sheriff, and California Highway Patrol held at the fire camp. Action plans and zones of responsibility were discussed and reaffirmed.

1830: Contrary to forecast the northeast winds did develop, the fire came to life and rapidly moved downslope into the developed and residential areas from Toro Canyon (north of Summerland) on the east and across San Marcos Pass Highway on the west (northeast of Goleta). Residents were evacuated and many houses burned. Winds continued through the night.

Fire camps were established at La Cumbre and Pendola.

September 24, 1964 - 0430-0700: Backfiring started along San Marcos Pass Highway toward summit in face of strong northeast wind. Forecast called for continued Santa Ana conditions throughout the day.

0600: Fire 26,000 acres in size and spreading rapidly.

Forces consisted of 10 air tankers, 4 helicopters (one large), 94 tankers, 54 tractors, and 1,400 firefighters.

1000-1400: Backfiring in the Painted Cave area completed to halt westward spread of the fire. Eight residences destroyed. Occupants evacuated.

1330: Southwest winds (opposite of forecast) developed pushing the fire away from the Painted Cave area and across the Camino Cielo along its full length of about 20 miles. Air very unstable.

Two crews along the Comino Cielo above Montecito caught and burned; 27 in one group and 7 in another, one fatally.

1330-1800: Fire crossed the Santa Ynez River at several locations out of control.

The fire was divided into 3 zones each with a Zone Fire Boss and full staff. A General Headquarters (GHQ) was set up.

Additional fire camps were established at Los Prietos, Polo Field, and Tucker's Grove. A GHQ also was set up at Tucker's Grove but soon was moved to the Polo Field at Carpinteria.

Control was established on the west flank after firing out in the Painted Cave area, but fire in the Santa Ynez drainage continued to spread. No further serious threat to Santa Barbara or other residential areas developed.

September 25, 1964-0600: Fire 51,000 acres in size. Forces 10 air tankers, 9 helicopters, 53 tankers, 54 tractors, and 2,367 firefighters.

General fire front moving into the back country toward Hildreth Peak across the Santa Ynez River from Jameson Lake to near Los Prietos.

September 26, 1964-0600: Fire 65,000 acres in size. Forces 11 air tankers, 14 helicopters, 49 tankers, 88 tractors, and 2,837 firefighters.

Heavy air tanker operation in the Hildreth Peak area.

Fire camp and new division established at Potrero Seco. Fire now organized into 4 zones with GHQ.

September 27, 1964-0600: Fire 66,000 acres in size. Forces 10 air tankers, 17 helicopters, 49 tankers, 92 tractors, and 2,577 firefighters.

Fire spread stopped in Hildreth Peak area with assistance of air tankers.

Secondary lines being constructed well beyond fireline.

1500: Zone - GHQ staff meeting on fire action and progress at Polo GHQ with all cooperators and the Chief of the Forest Service attending.

Mono fire camp established.

The fire spread was now virtually stopped and it became a matter of completing many miles of hand line in difficult and inaccessible country. Forces remained at near full strength on September 28 and 29 and then were gradually demobilized. Control was declared on October 1, 1964. Mopup continued for several weeks thereafter.

MUTUAL AID ARRANGEMENTS

1. Pre-Emergency: A large amount of cooperative aid was quickly mustered and brought to bear to suppress the Coyote Fire. Most of this assistance was supplied under existing arrangements and among the fire and police agencies and other cooperators in the area. The Los Padres National Forest has co-op agreements of varying complexity with all of the fire agencies listed in Section II, p. 14 of this report. Many cooperators have similar agreements among themselves. Examples of representative agreements can be found in the Project 229 report on mutual aid arrangements in Los Angeles County, California.[3/]

   These agreements have been developed over a period of many years as a result of common need. They have been improved and refined through frequent use. However, not all of these agreements are formalized in writing and signed.

3/ "Los Angeles Mutual Aid Study," by T. G. Storey and C. L. Harrison. Project 229, National Fire Coordination Study, USDA, Forest Service, Division of Fire Control, 109 pp. March 1965.

A somewhat unique assistance agreement is the Disaster Abatement agreement among protection agencies of the south coast of Santa Barbara County (Appendix E). Parties to this agreement are the Forest Service, Santa Barbara City and County, and the Fire Districts of Montecito and Carpinteria. Listed as facilitating agencies are the County Sheriff's Department, City Police Department, California Highway Patrol, Red Cross, utility companies, transportation companies, newspapers, and radio stations, among others. The agreement specifies a plan of action for emergencies, particularly from fire, which provides for initial attack, setting up a control board of strategy, and providing adequate communications. The Fire Boss feels that cooperation fostered by this agreement greatly facilitated cooperation among the parties involved on the Coyote Fire.

Of course, all fire agencies in the area are parties to the State Fire Disaster Plan of the California Disaster Office (CDO). Civil Defense fire tankers and crews from the southern half of the state were provided under this plan.

Most of the tractors and other rental equipment used on the fire were provided under existing contracts between the Forest Service and the vendors. Usually these contracts are signed each year and

cover the fire season. Most of the air tankers and helicopters were provided in this manner.

The California Division of Forestry (CDF) contracts the job of rural fire protection in Santa Barbara County to the County. However, CDF units from other counties provided a great deal of assistance in the form of personnel, equipment, and service to the Forest Service on the fire.

2. Performance in Emergency: It appears that mutual aid arrangements worked well in the emergency. There was prompt multi-agency response by the Forest, Santa Barbara City, and Santa Barbara County. All three sent reinforcements commensurate with the need as the situation worsened.

Other agencies responded upon request according to plan. Fire and police agencies provided liaison on the Fire Boss' staff and provided communication links.

The Forest Service was in overall command from the start since the fire occurred within their contractual protection boundary. The fire control line and staff organizations built up smoothly as the emergency increased in scope.

Hand crews, tankers, dozers, and air attack were obtained with a minimum of delay from pre-arranged sources through established dispatch channels.

Civil Defense pumpers, repair units, crews, and liaison were provided promptly in the amounts requested. Request channels were followed in most instances.

3. Agency Assignments on Fire: In general, agencies were assigned jobs commensurate with their training and abilities. City fire departments were assigned to urban sections of the line. County fire units were assigned to urban portions of the line or to adjacent rural sections, generally in their normal areas of jurisdiction. The Forest Service handled the rural portions of the fire and overall command.

Incoming mutual aid units reported to the unit originally requesting them. The two then worked together until their section of line was controlled or a greater need developed elsewhere in which case the responding units were passed along. Responding units were assigned to work with local units whose personnel were familiar with the country.

In Santa Barbara some urban-type fire trucks from adjacent cities were used to fill in behind Santa Barbara's equipment at stations in sections of town remote from the fire action. This released Santa

Barbara's units to work on the fire. Most of this activity was in accordance with existing mutual aid arrangements.

4. Handling Requests for Mutual Aid: Most requests for mutual aid were handled smoothly according to pre-arranged disaster plans.

The Forest Service, Montecito Fire District, and the Santa Barbara City and County Fire Departments were involved immediately because the fire occurred in their joint initial attack zone. When it became evident that a campaign fire was developing, the local agencies involved started requesting mutual aid under terms of their various agreements as follows:

Requesting Agency	Supplying Agency
County of Santa Barbara	California Division of Forestry
County of Santa Barbara	Ventura County
City of Santa Barbara	California Disaster Office
City of Santa Barbara	City of Los Angeles
U. S. Forest Service	County of Los Angeles

Although individual agencies requested mutual aid, they did so, in most instances, only after consultation with the other local agencies represented on the Fire Boss' Coordination Board.

5. Problems Encountered: There were several instances of confusion and misunderstanding in ordering and supplying men and equipment under mutual aid. None appears to have had an adverse effect on fire suppression. Nevertheless, they do indicate areas of mutual aid arrangements that may need improvement.

Requests for CDO pumpers should go from the Forest Service through the California Disaster Office (CDO) Area Fire Coordinator. If the AFC is unable to fill the request, he passes it on to the Regional Fire Coordinator. This insures proper channeling of requests for CDO pumpers in mutual aid situations.

A number of military units from several different home bases were used on the fire. Ordinarily the senior officer present has operational charge of all units in the area. Close liaison must be maintained between the senior officer and fire administrators. Some military units tried to do business direct with their home bases, causing difficult cross-communication problems.

There were isolated cases of units pulling off the fireline without permission and refusing to work. Fortunately these instances were rare. One military unit departed the fire

prematurely without permission. This indicates a need for closer liaison as mentioned above.

The limited range of most urban fire pumpers, because of their dependence on hydrant hookups, was a serious problem in several instances on the Coyote Fire. Line was lost at critical times because these pumpers couldn't get water to the fire.

6. Suggestions for Improvement: Existing mutual aid agreements appear to be adequate both in number and content to handle any emergency as large as the Coyote Fire or somewhat larger. However, more of them probably should be formalized in writing. Unless agreements are spelled out there is a tendency to forget their exact terms, especially in crisis situations. On the other hand, too much formality, particularly in fiscal arrangements, sometimes affects the spontaneity and free flow of mutual aid. Each case should be examined and judged individually.

There appears to be a need for better mutual understanding of dispatch channels to follow in mutual aid situations. People are rushed, communication channels are crowded, and mixups are bound to occur. The answer to this would appear to be joint agency training for emergencies.

Instances of failure of responding units to report in to the requesting unit on arrival at the fire, pulling off the line prematurely, and refusing to work, points up the need for more joint training in these areas. Much of this undoubtedly resulted because the individuals involved did not understand the principles of rural fire behavior, suppression methods, and fire organization. This was also observed on the Santa Rosa fires.

There is a definite need for equipping and training "mountain units" from among the urban fire departments situated in the front country for fire emergencies. Equipment must carry its own water in large quantities and be able to draft water. Joint training with the rural fire services is essential.

Adequate liaison must be provided to responding organizations. Joint agency training, and more specific instructions would help here also.

COMMAND ASSIGNMENTS and ORGANIZATION STRUCTURE

1. Pre-Emergency: Within the Forest Service the organizational structure for large fire suppression is specified in the Manual. The fire commander is designated Fire Boss. He has a staff and line organization under him. Primary staff positions are Plans Chief, Service Chief, and Finance Chief. The primary line position is the Line Boss who has two or more Division Bosses under him, and if an air attack organization is used it is also under his supervision. Each Division is further broken down. Appendix F illustrates the fire organization for the day shift on September 23.

On very large and complex fires such as the Coyote Fire the organization may be expanded to a General Headquarters (GHQ) organization. Two or more Zone Fire Boss positions, each with a complete line and staff setup are established under the GHQ Fire Boss. The GHQ Fire Boss is also supported by a staff organization. A duplicate set of records for each zone is kept at GHQ. The GHQ Fire Boss is in overall command. Liaison representatives from all cooperating agencies are stationed at the GHQ. The GHQ organization for the day shifts, September 27 is given in Appendix G.

Wherever a fire occurs in the joint mutual attack zone in the Santa Barbara area the ranking man of the "first-in" organization is in command. A representative of the organization responsible for protecting the area takes over when he arrives. As the fire grows in size urban departments are assigned to urban sections of the line, the County is assigned to mixed urban-rural sections and the Forest Service usually handles the wildland portions of the fire. Actually, the Forest Service, by mutual consent, usually assumes command of fires in the suburban areas near the City limits or beyond.

2. Performance in Emergency: Assumption and transition of command was made smoothly and without difficulty. Command of the fire changed 4 times in the first two hours.

From initial attack at 2:06 p.m. September 22, until arrival of Santa Barbara District Assistant FCO, the Mt. Drive Foreman was Fire Boss. District AFCO assumed command as Fire Boss at 2:12 p.m., until arrival of the District FCO.

District FCO assumed command as Fire Boss at 2:15 p.m. until about 4:00 p.m., when the fire spotted across the fuel-break and it became obvious that a major fire was developing.

The Forest FCO had arrived at the fire about 2:30 p. m. assisting the District FCO in organizing the initial effort. He assumed command at about 4:00 p. m.

On September 23, plans were made to organize the fire into a GHQ with two zones and establish an additional camp at Pendola. Forest Supervisor Hansen assumed command as GHQ Fire Boss, about 10:00 p. m., September 23. FFCO Hickerson assumed command of Zone I, headquarters at Westmont Fire Camp, and all the fire area south of Camino Cielo. San Bernardino N. F. FCO Britton assumed command of Zone II, headquarters at La Cumbre (later Pendola) Fire Camp, and all the fire area north of Camino Cielo.

The fire continued under a GHQ type of organization through control on October 1st.

RESOURCE INVENTORY, DISPATCHING, AND LOCATOR SYSTEM

1. Pre-Emergency: The Los Padres National Forest operates on decentralized dispatch system, whereas most Forests in Region 5 have adopted the centralized dispatch system.

The 7 Ranger Districts on the Los Padres Forest each have a clerk-dispatcher. The dispatcher for the Santa Barbara District, where the fire occurred, is located in the main Post Office building in down-town Santa Barbara.

In a fire emergency, the District Dispatcher first dispatches all available resources from the District. If this is not sufficient he will notify the Forest Dispatcher also stationed in Santa Barbara. He, in turn, will dispatch the resources of the Forest. If the Forest cannot supply the resources needed, the Southern Zone Dispatcher in Arcadia, near Los Angeles, is notified. The Southern Zone Dispatcher arranges aid from the other National Forests in the Southern Zone, from the Northern Zone (Redding), and from the California Division of Forestry (CDF). If assistance from other Forest Service Regions is required, the Regional Forest Service Dispatcher in San Francisco is notified. The RFSD will make the necessary contacts to obtain Inter-Regional assistance if needed.

Local City and County fire agencies in mutual aid handle their dispatching needs through their regular dispatch channels. They have communication tie-in with each other and with the Forest Service.

The various dispatch offices maintain complete directories and lists of the manpower and equipment available for them to request and dispatch. Card file systems are the most common means used to record and retrieve data quickly when needed. A variety of maps are used which are mounted on boards so they are readily visible. Complete radio and telephone nets are maintained. Wall charts are commonly used to record names and numbers of men and equipment.

In the fire camps the Forest Service dispatcher has forms for recording information on available men and equipment.

2. Performance in Emergency: Dispatching performed smoothly during most of the fire action. However, the dispatch organization did not build up in proportion to the fire organization early enough to take care of the buildup in business. Consequently, there was a tendency for line units to bypass the dispatch office to get necessary service. This involved the service sections at the fire camps, also.

Locator and inventory systems worked adequately.

3. Arrangements for Keeping Command Informed: Complete records of crews, equipment, and assignments are kept on pre-printed detailed forms by the Plans Section at the fire camp. Thus the Fire Boss could determine at any time the status of the organization.

COMMUNICATION SYSTEMS

1. Description: Three separate radio nets were used besides the Regional air net and the Forest net. The service section of the fire handled their business over radio-telephone, plus 16 miles of helicopter-laid land line. Mutual aid units generally brought their own communications and provided a link at the fire camps and GHQ.

2. Effectiveness: The radio and telephone communications were satisfactory. The copter-laid land line materially assisted Zone II with their business at Pendola Camp. It was installed quickly using a military-type wire feeding device. Existing telephone lines to Pendola were burned out by the fire early in the action.

FIRE PROBLEMS NEEDING SOLUTION

The fire was nearly controlled at three different times during the early stages. Sufficient manpower and equipment were mobilized at the scene of the fire to do the job but lack of sufficient access precluded proper distribution of forces at the perimeter of the fire to be effective within the time available. The three critical instances were:

1. Within the first 10 minutes the fire was almost stopped, but a large live oak crowned, causing spot fires.

2. The fire was lined at 15 acres and spread was stopped but a burning house spread two spot fires across the line.

3. Between 6 and 8 p.m., the fire slowed and a major effort was made to cut off the head. At about 8 p.m., spreading fire outflanked the line and spread rapidly with strong gusty winds. Crews missed closing the line by 25 chains (1650').

Air attack was dispatched on initial attack but approach to the fire was hampered by powerlines and dense smoke so planes were forced to approach too high and at wrong angles to be effective. The possibility of use of helitankers in this kind of situation should be considered.

Study is needed of planning principles for very high hazard, high risk, and high value areas with particular emphasis on the economic balance between road access, helispot access, fuel break access, and preparedness organization needs.

The infrared scanner, while still in the testing phase of development by the Forest Service, was used on the Coyote Fire. The Fire Boss and Plans Chief indicated that timing of flights to get material to plans section for use on the next shift was not right. When infrared fire mapping becomes operational, official guidelines will be issued showing the Fire Scan Officer's place in the fire organization.

It is important for fire command to realize the limitations in the art of forecasting fire weather. Often command wants forecasts for specific small drainages. This is very difficult but there is a need to be able to forecast sudden changes in weather elements, such as wind and humidity. This affects buildup in presuppression forces and specific actions on fires.

Instances were observed of the failure of command to use fire weather and behavior forecast after they were issued.

PROTECTING KEY BUILDINGS AND STRUCTURES

A total of 188 structures, mostly residences were destroyed or damaged on the Coyote Fire. Effective suppression action saved an undetermined amount of property.

Pre-emergency measures that were effective in saving structures were brush clearance around structures, use of fire-resistive roofing and adequate access roads and turn-arounds in brush areas. In general, residential portions of the fire area ranked poor on all three counts. Public Law 643, 1964 requiring brush clearance, and the new Fire Safe publicity program are steps in the right direction but compliance with the law is slow and the prevention campaign has just recently gotten underway.

1. Effective Tactics: Pumping water directly on the roof and walls was the most effective tactic used in saving residences. This had to be done just ahead of the fire and before the structure became too heavily involved. Almost no structures were lost among those that firefighters were able to get to before they were seriously involved. However, it was much more difficult to protect structures where brush had not been cleared.

Many structures were lost because access roads were too narrow to risk tankers and men on them when the fire was close by, even though tankers were available.

A dormitory at Westmont College valued at $200,000 was the most important structure destroyed by fire. The dormitory burned on the second night, September 23-24, after the winds changed to downslope moving the fire into Santa Barbara. Pumpers were massed but efforts to save the buildings were unsuccessful.

Direct air attack was able to save structures at Painted Cave in the forenoon of September 24. This tactic was very effective and shows much promise for use in post-nuclear attack fire suppression and other peacetime fire emergencies. Air attack also was used to save structures in Los Prietos and Paradise later in the emergency. Air attack could not be used directly for saving structures on either September 22 or September 23 because the big runs into populated areas occurred at night.

2. Important Decisions: Structures became involved shortly after the fire started. Suppression forces were in short supply at the time and firefighters were working in the brush attempting to get a line around the head of the fire. Suppression efforts were diverted in an attempt to save the previously evacuated structures.

Had they continued with line building it is possible the fire would have been held at about 15 acres. Forest Service crews as well as urban department crews were involved at the time.

The Painted Cave Road was backfired on September 24 in a successful attempt to stop the westward spread of the fire and to protect the bulk of the 60 homes in that area. Joint consultation between top fire command preceded the decision to backfire. It was recognized that the backfire might endanger a few homes but the risk was judged to be worth the benefits to be gained. Heavy air attack was concentrated on the area following ignition and contributed to saving many homes as the backfire and main fire merged. Eight homes were destroyed by the westward spread of the main fire shortly before the backfire took hold.

Several miles of backfires were used on the Coyote Fire. Much of it was successful in protecting urban areas. Trouble was experienced on the evening of September 23 when a wind shift caused the loss of much line near Santa Barbara. The line had been backfired just prior to the abrupt change in weather. This lost backfire resulted in the loss of several structures.

Following the wind switch on the night of September 22, the fire threatened the Mt. Drive Fire Station located near the fire origin. A pumper was sent back to protect the structures. This action was successful.

3. Relation to Protecting People in Shelters: The urban areas that burned consisted of residences and outbuildings widely-spaced on large lots along narrow, winding, streets with heavy brush between structures. Brush contributes most to the total volume of available fuel in this fuel type. Persons trapped by fire in such a situation would have an excellent chance of surviving if they had access to a closed shelter they could enter briefly until the fire passed over. Fire in brush burns hot but doesn't last long. The structures might burn for longer periods but surrounding brush areas would cool down quickly.

It is doubtful that an oxygen shortage would develop, lethal concentrations of gas would build up, or that air would be heated excessively in the shelter in such a short period. Many cases are on record, including the Coyote Fire, in which firefighters caught in brush areas while attempting to save structures merely stepped inside or behind the house until the fire in the brush passed by. In some instances they were able to save the structure. This becomes more difficult where the brush is very heavy, grows close against the house, and exterior and roof are flammable.

There was at least one instance on the Coyote Fire of residences using prepared shelters to escape the fire. Residents of the Hot Springs Club successfully sought refuge in a shelter dug into a hillside on the Club grounds, even though there was no provision for a supplemental air supply or special ventilation. This shelter, built years ago specifically for this purpose, had a thick masonry entrance and heavy steel door.

More than one instance of residents taking temporary refuge in swimming pools were reported. They simply ducked their heads in the water as necessary when gusts of hot air approached.

COST-BENEFIT FACTORS IN STRATEGIC DECISIONS

Cost-benefit factors entered into many of the decisions made on the Coyote Fire. The most effective method known for determining cost-benefit factors and making key decisions is the informed judgement of a thoroughly trained and experienced fire commander based on intelligence information including good fire weather forecasts.

1. Values Sacrificed: On any project fire, command is faced with decisions where one value must be sacrificed at the expense of another. Decisions of when and where to backfire are the most common. Many such decisions were made on the Coyote Fire including the following:

a. Decision to divert the initial attack crew to protect the structures near Mt. Drive rather than continuing full effort to put a line across the head of the fire.

b. The Painted Cave decision where a backfire was used that would probably destroy a number of homes, but with the planned result of "picking up" the west side of the fire as well as saving a settlement of 60 homes.

Many similar decisions to backfire were made that are not given publicity because only wildland fuels were involved.

There is a natural inclination to try to save high-value property such as the structures in the Mt. Drive incident. It wasn't clear whether this decision was made by the tanker crews themselves or the Fire Boss at the time.

At Painted Cave it was decided that the benefits to be gained from backfiring would be worth the sacrifice of a few houses. It should be pointed out that many additional miles of line were backfired on the Coyote Fire, many of them adjacent to residential areas. These tactics saved many homes. Fortunately none of these other backfires had to be done in situations where homes had to be included in the area to be burned by the backfire as at Painted Cave.

2. Responsibility for Decisions: This rests with the Fire Boss. At Painted Cave the line overhead sized up the situation on the ground and formulated a plan. The plan was presented to the Fire Boss who made the decision to backfire. He did this only after carefully weighing the alternatives and consulting key cooperators. The Fire Boss had unanimous support in his decision by knowledgeable individuals involved.

3. Values Gained: It is almost certain that had Painted Cave Rd. not been fired out, the entire group of homes valued at perhaps $1,000,000 would have been lost. Also, the fire probably would have continued to spread westward burning additional homes and wildlands and requiring further suppression expenditures.

On the other hand, the Mt. Drive decision may have saved a few structures at the expense of 67,000 acres burned and many more structures destroyed.

STRATEGIC RE-DEPLOYMENT OF FORCES TO PROTECT KEY AREAS

1. Description: On Wednesday night September 23 the wind shifted from upslope to downslope driving the fire into urban areas along a front many miles long. Some units that had been fighting the fire in the mountains were pulled back for an all-out effort to save the cities. Control action continued against the rural portions but at reduced strength. Urban units were used in the city defense whenever possible, with some Forest Service units assisting. Fire command had been assembling additional urban fire units for several hours in anticipation of a worse city threat.

   Movement of rural fire forces from the hills to the city defense was orderly and according to plan. Air attack was grounded because of darkness.

2. Action: It was obvious that, in this case, the urban threat was of overriding importance. Thousands of homes were vulnerable. Selected units and crews were ordered to fall back. Orders were passed by radio. Chain of command was followed. The forces involved in defense of Santa Barbara and adjacent cities are estimated at 90 tankers, 50 tractors, and 1,200 firefighters.

Losses were held to 60 homes destroyed and many damaged. This effort was considered quite successful considering the potential threat to homes and communities.

EMERGENCY EVACUATION OF PEOPLE

There were many separate instances of evacuation on the Coyote Fire. All were successful in that no lives were lost among the thousands of residents involved although 188 structures were destroyed or damaged.

The largest evacuation efforts occurred Wednesday night, September 23, when wind shifts caused the fire to threaten the front cities, and on Thursday morning when the residents of the Painted Cave community were threatened.

1. Methods Used: Evacuation of Santa Barbara was handled by the Santa Barbara Police Department, Santa Barbara County Sheriff's Office, and the California Highway Patrol. This was under terms of the Disaster Abatement Agreement (Appendix E). These law enforcement agencies also provide roadblocks, traffic control, and protection against looters.

   Officers moved through the threatened areas issuing requests to evacuate by loudspeakers, bullhorns, and verbally. Local radio stations broadcast the requests. Compliance was good although some persons stayed on to try to save their homes.

The Santa Barbara Sheriff's Office evacuated Painted Cave. More difficulties in getting people to leave were encountered here. All but a few were finally persuaded to leave. Some stayed and a few were able to help save their homes, although at great personal risk. As far as is known no one was forcibly removed in either situation, although this may have been used as a threat.

2. Responsibility for Decisions: The sheriff and representatives of other agencies contributed to a joint decision to evacuate. This was a GHQ multi-agency command decision. Evacuation was done a reasonable time in advance of the fires arrival. Compliance isn't as good if it is attempted too far ahead. There isn't the sense of urgency about it that will prompt people to comply.

3. Problems Encountered: The usual problems of convincing some people to leave their homes when there is a chance of saving it were encountered in both instances.

Access for evacuation and for fire control action was extremely poor. Roads were narrow, one-way, steep, winding, and brush-choked. Frequently brush and tree canopies grew together over the road.

SYSTEM AND BASIS FOR ESTIMATING CONTROL FORCE NEEDS

1. Description: The Forest Service has established systems for estimating control force needs on a fire. Information is gathered by air and ground scouting. Factors considered included present location and size of the fire, fuel type, estimated rate of spread, weather, and equipment available. Computations can be made using tables or a circular slide rule-type calculator. Early in a fire before all aids are available, estimates may be based on experience.

2. Effectiveness: Estimates were generally accurate as long as the weather, particularly wind direction, didn't change. These estimates definitely were helpful in fire control planning. Estimates produced are only as good as the input information. In general, there was adequate air and ground scouting to accurately determine the inputs of fire location and rates of spread.

3. Problems: Unexpected wind reversals sometimes negated carefully drawn control force estimates.

CONTROL OBJECTIVES

On all fires, control objectives are set by the Fire Boss as soon as he is able to size up the situation. Specific objectives are revised as necessary depending on the success of initial attack and subsequent control action. As the fire grows in size the objectives may become more general. For instance on September 24 several thousand acres were burning and there was much open line. The objective set at this time was to hold the fire along the San Marcos Pass Highway on the West and along Camino Cielo on the North.

1. Setting Objectives: Objectives are set by the Fire Boss in conjunction with the Plans Chief (Plan Coordinator in GHQ setup) and Line Boss with other consultation as necessary. When a fire is still small, one man may fill several positions but the organization remains essentially the same.

   Later in the fire more specialists were consulted in making decisions on objectives. However, the judgement of experienced fire commanders remains the most essential factor in setting good objectives.

2. Factors Considered: Factors considered in setting control objectives include location, size, behavior, and rate of spread of the fire, fire weather, fuels, topography, location of natural barriers, values at stake, and type and availability of equipment and assistance. All this information is integrated to arrive at an objective.

Objectives must be changed to adapt to changing conditions. Adherence to outmoded objectives can be wasteful of time, equipment, manpower, values at stake, and even human lives.

In a nuclear attack situation, the arrival time of fallout would have to be considered in setting control objectives. Since this period usually is rather short it would appear that incipient fires would have to be attacked more quickly and in greater force than at present. After a maximum of perhaps one hour, depending on the attack, suppression forces would have to seek shelter from fallout. It might not be safe for them to emerge for several days thereafter.

3. Success: Objectives established at various points during the Coyote Fire appeared reasonable. Objectives were changed promptly in response to changing conditions.

TACTICS AND EQUIPMENT

Tactics consisted primarily of a combination of direct and indirect attack on the head, flanks, and rear of the fire. Indirect attack was accomplished using hand-constructed line, tractor-built line, retardant line laid by aircraft ahead of the fire, and backfired lines. Direct attack on the fire included the techniques of retardant drops directly on the fire, water applications by tankers, and lines built by hand at the fires edge. Existing roads stopped certain portions of the fire without supplemental widening.

During the main urban threats, pumpers were massed at the urban fringe and were used primarily to protect individual structures as the fire approached and passed by. Some backfiring out along roads was done as the fire swept into town. These lines were rather ineffective in most areas and the fight resolved into a series of individual actions with tankers attempting to save structures while the fire burned by in the adjacent brush.

Air attack was successful in protecting key areas, structures, and, in one case, trapped firefighters. Retardant drops saved many homes in the Painted Cave area Thursday morning September 24.

The Gibraltar Saddle rescue operation that same afternoon was materially aided by air attack. A flareup had trapped a crew of firefighters. Concentrated air attack on the spot held the fire in check until ground units could bring out the burned and injured men. Helicopters landed nearby to carry them to hospitals.

The firing-out operation at Painted Cave where air attack was used to protect residences until the fire was safely past is a technique worthy of further study for possible application in other fire emergencies. Tactics used by air attack at Gibraltar Saddle to protect life also has application in civil defense.

PRE-DISASTER PLANNING AND PREVENTION

1. Measures Taken: In the Santa Barbara area each agency and fire service maintains an organization capable of handling the ordinary fire business. None has the resources to cope with disasters without assistance. As explained earlier the fire services have banded together to assist one another in these emergencies, under mutual aid agreements.

   Agencies do not hold joint training sessions; however, each appears to have a good understanding of the problems, capabilities and resources of the others.

The urban fire departments maintain fire stations in the "front country" sections of town. Some are equipped with 4-wheel drive equipment with large tanks that are useful in hilly suburban sections. Most personnel assigned to these stations have some rural fire control training and experience.

County departments generally are staffed, trained, and equipped to fight fire in the brush.

The Forest Service has installed a pre-attack system on most of the Los Padres Forest. It consists of prepared and permanently marked locations of water sources, tanker fills, equipment parking, tractor unloading, turn-arounds, fuel breaks, access roads, and trails. This system has proved very helpful in fire emergencies.

The Forest and County now have a fairly complete system of fuel breaks, roads and trails. Most of the net is marked and mapped for quick location and is well maintained.

For years the City and County have been fighting a losing battle to limit building in the mountainous sections, promote use of firesafe construction, and to get homeowners to maintain firebreaks between structures and the surrounding brush and trees. Existing ordinances have been inadequate. California Public

Law 643 passed in 1964 is more specific and provides stiffer penalties for non-compliance. The situation should improve when this law is fully implemented.

2. Need for Additional Pre-Disaster Action: Additional prevention personnel are needed to carry out the provisions of Public Law 643.

Since the Coyote Fire the County has adopted the Uniform Fire Code. The County also has passed (December 3, 1964) an ordinance, County Ordinance No. 1600, relating to fire resistant construction and other protection for buildings in high hazard areas.

The Forest Service has allotted money for a "crash" program of type conversion and fuel break construction within the burn providing for construction of 50 miles of fuel break and 7,500 acres of type conversion.

The Santa Barbara County Board of Supervisors has appointed a committee to study the possibilities for controlled burning of vegetation as a brush removal and fire prevention measure.

Some people who live in the fringe areas of the high hazard brushlands do not realize they may be vulnerable to fire loss. The Forest Service has undertaken to notify these people in writing of their peril. This applies to occupancy within National Forest protection boundaries only.

TRAINING OF OVERHEAD AND SUPPRESSION FORCES

1. Agencies: Each fire agency in the Santa Barbara area conducts intensive training in their areas of primary responsibility. City departments train primarily in structural fire control, the County in structural and rural fire control, and the Forest Service primarily in rural fire suppression.

   Selected City crews attend brush firefighting schools conducted by the County, State, and Forest Service. Selected Forest Service crews receive training in structural firefighting. However, the bulk of the fire training is done within the agency.

   There is no joint agency training for large fire emergencies in the Santa Barbara area. As indicated above there is joint training of small groups of personnel for specific facets of the job only.

   California Disaster Office equipment and personnel do not participate in Forest Service rural fire schools.

2. Methods and Equipment: Training consists of instruction in the classroom, in the field, and continually on the job. Qualified instructors, modern training aids, and methods are used. The Forest Service conducts within-service schools in all aspects of

large fire management including categories of line and staff functions, dispatching, and air attack. They do not conduct actual full-scale mock field problems. Other agencies do not participate to the full extent they do on actual large fires. Police, institutional representatives, and similar cooperators do not train with them on a routine basis. The training each agency conducts prepares its personnel very well for their routine fire business. Problems arise in joint agency fire emergencies such as the Coyote Fire where all agencies must work together, frequently out of their normal environment.

The Coyote Fire revealed that urban crews may lack sufficient training in rural fire control and that their equipment is unsuitable for use off the road and away from hydrants. This seriously restricts their range and effectiveness in rural-urban fire threat situations.

3. Training Recommendations: Joint agency training for large fire emergencies should be explored. All pertinent fire, Civil Defense, and law enforcement agencies should participate. Conditions should be as realistic as possible.

1. Adverse Effects On Control: The hazardous condition of rural and urban fuels was largely responsible for the Coyote Fire igniting, escaping initial control, and for its subsequent spread.

The two most damaging fires in California in 1964 involving the Forest Service (the Coyote Fire and the Cozy Dell) started in grass fuels near road edges. Both might have been prevented by good roadside hazard reduction work.

After escaping initial attack the Coyote Fire quickly involved several structures. These structures had inadequate clearance from the brush, were sub-standard construction, and access was inadequate. Brands from the burning structures carried the fire across the Montecito fuel break, initiating the campaign phase of the fire.

In the subsequent cases of urban threat similar problems were experienced. Fire was readily communicated from the brush to structures and back to the brush. Combustible roofs produced brands that carried fire up to 1/4 mile or more to ignite brush and other structures. Wood roofs ignited readily from brands of all types.

Most roads on the city fringe were too narrow to permit safe backfiring when use of this tactic was indicated. Roadside brush made many roads too dangerous to risk fire equipment on them. This caused many houses to be destroyed that otherwise might have been saved.

2. Favorable Effects On Control: Fuel breaks that had been built to standard stopped, or materially slowed the fire, at least temporarily, in several areas. Houses with proper clearance from the brush survived the fire much better than those surrounded with brush. Where adequate access was provided, firemen could enter and pump water on the structures.

FATIGUE FACTORS

Fatigue was no particular problem among commanders or other overhead on the Coyote Fire. Because of adequate numbers of overhead, they were able to get sufficient rest.

Use of helicopters to move men to and from the line and for scouting contributed greatly to minimizing fatigue problems at all organizational levels throughout the action.

Firefighters were rotated at adequate intervals so they had proper rest.

WEATHER FACTORS-SUMMARY

Areas that fall within the marine air influence, such as Santa Barbara are very complex as to weather pattern. It is particularly difficult to forecast the local weather situation for specific elevations in the mountains and for specific small drainages. Yet, this must be attempted because these weather forecasts and the fire behavior forecasts derived from them provide vital inputs for decision making by the fire commander.

1. Prevailing Situation: The weather that prevailed during the fire was generally unfavorable from the standpoint of fire behavior and fire suppression. The wind was strong, frequently gusty, and changeable. Humidity was persistently low which enhanced fuel dryness. Temperatures were generally high. However, it was the sudden, unexpected reversals in wind direction which caused the biggest problems in fire suppression. Some of the fire command felt that these changes were not forecast accurately enough.

2. Effect on Fire: There were at least three critical wind reversals on the Coyote Fire. The first occurred during the first night, September 22 when the wind changed suddenly from upslope to downslope carrying the fire over the west and south flank into populated areas of Santa Barbara.

The second case occurred about the same time the following night, September 23, but with more disastrous results. The fire was much larger this night when the wind switched so the fire was spreading along a much broader front when it swept into the cities. It also persisted for a longer period of time.

The third event, which involved primarily the fire situation in the Painted Cave area, occurred about noon September 24. At this time the wind, which had been blowing steadily from the northeast, switched suddenly 180 degrees to the southwest. This caused the head of the fire which was about to engulf the homes in Painted Cave to become a backing fire. This fortuitous event, combined with prompt backfiring of the Painted Cave Road, saved all but a few houses in the area and permanently halted the fire's westward spread.

Fire Weather Forecasts and Fire Behavior Forecasts for the second and third critical periods are included in Appendix H. The original Fire Behavior Forecast for the night of September 23 mentioned the possibility, (labelled a caution), that the strong Santa Ana winds from the northeast would surface again that night. While only a 10 percent chance was given for this to happen, the wind shift occurred and as observers on the ridges detected the onset of the wind switch they immediately notified the Fire Behavior Forecaster.

He prepared an amended forecast and promptly notified the Fire Boss at 7:30 p.m. Crews on the line were alerted at once.

The Fire Behavior Forecast for the day shift September 24 in the Painted Cave area indicated westerly spread at high levels, the general level of Painted Cave. The forecast didn't mention that upslope winds were a possibility although they were predicted for adjacent sectors. Southwesterly winds did develop starting about noon.

The above forecast strongly indicated there would be generally erratic fire behavior during the day. Erratic fire behavior was partially responsible for trapping the two fire crews in the early afternoon of September 24 at Gibralter Saddle. A number of fire-fighters were burned, one fatally, in the two seperate incidents.

The Fire Weather Forecast units were provided by the U. S. Weather Bureau and the Fire Behavior Forecast unit provided by the Riverside Forest Fire Laboratory. The services provided by these units were vital to the suppression effort. They would be equally valuable for coping with the fire problem following nuclear attack.

Fire weather forecasting and fire behavior forecasting involve many difficult problems. Increased research effort in these fields is urgently needed.

ADDITIONAL UNFORESEEN SITUATIONS

An unexpected problem involving movement of equipment developed during demobilization of forces after the Coyote Fire was controlled. Many overweight tractors were used on the fire. These were allowed on the State highways to get to the fire, but trouble developed with highway officials in getting them home. Rulings by highway officials to the effect that after the fire was under control the emergency no longer existed caused long delays and added expense getting such equipment back to home base. This points to possible problems in other sections of the country but this would probably not be a problem during a nuclear emergency. Negotiations have been started with State officials to arrange for blanket permits for use of highways in emergencies.

There seems to be a serious question concerning how many access roads are needed or can be afforded. The problems evolve around a proper balance of access, manpower, prevention, machinery, fuel treatment, and other fire control facilities and aids. It seems that some careful cost-evaluation studies on these matters are needed. Operations research and system development techniques might be applicable to this problem.

IV. CONCLUSIONS

From the analysis of the Coyote Fire, we can conclude or assume the following:

1. Pre-emergency arrangements should provide for; (a) mutual aid, (b) command assignments, (c) evacuation measures, (d) other details for emergency operations.

2. The effectiveness of multi-agency operations in emergencies is tied closely to how well cooperators work together. How well they work together depends a great deal on how much they train together and/or how often they work together.

3. The Coyote Fire Study shows the need for better dispatch systems and aids to handle channeling of requests, orderly requisition of supplies, assignments, and multi-agency situations.

4. Command and Service personnel must have the ability and training to plan ahead in emergencies. Otherwise, resources will not be on hand when needed.

5. Existing systems for location and inventory of resources work satisfactorily. Competent, experienced dispatchers are essential for existing systems to function properly.

6. Cooperating agencies should if possible, be assigned jobs that are in line with their past training and capabilities. If cooperating agencies are to be used in other capacities, they will need pretraining to do safe, effective work.

7. Procedures for reimbursement for use of Civil Defense fire equipment and other borrowed equipment should be clearly specified in pre-emergency arrangements in order to avoid mixups when the crisis occurs.

8. Emergency communication systems including land lines laid by helicopter are needed to handle the traffic in a large fire situation. Traffic on primary radio networks must be relieved and burned out line replaced.

9. The infrared fire mapping scanner proved to be a useful tool on the Coyote Fire.

10. Key buildings of smaller size can sometimes be protected from fire by conventional tanker and engine equipment with normal-size crews provided an adequate water source is available.

11. Air attack with retardants is effective in protecting individual residences from fire in situations untenable or inaccessible for ground forces.

12. Most persons will voluntarily evacuate their homes when threatened by fire if the need is made evident to them; however, many individuals will insist on staying, in an attempt to save their homes.

13. Private citizens will assist one another in fighting fire and otherwise helping in emergencies even when they have no personal or financial interest in the outcome and are themselves in danger.

14. It is important to set clear control objectives in a fire emergency. This forms the basis for estimating resource requirements.

15. Volunteers can be integrated into the suppression operation in fire emergencies if they can be given reasonable on-the-job training prior to assignment.

16. Adequate access for equipment and personnel is vital in order to suppress fires promptly. Obstructions include inadequate roads, thick brush, and traffic congestion (vehicle and pedestrian). Power lines, terrain, and smoke can seriously limit access for air attack.

17. Logistics and action timing capable of controlling fires in peacetime may not be realistic where fallout is involved.

18. Much needs to be done in the way of fuel treatment and hazard reduction to make our urban and rural areas less vulnerable to fire. Fuel breaks and roads are effective as fire breaks when wide enough for backfiring and when so used.

19. Fatigue among fire command can be a problem This would be more likely in emergencies much larger and widespread than the Coyote Fire and in nuclear attack situations where replacements might not be available.

20. Fire Weather and Fire Behavior Forecast teams provide a vital service to the fire command in fire emergencies.

21. In addition to current use, helicopters show great promise for use in large fire emergencies resulting from enemy attack.

22. Urban fire services in areas of rural-urban interface need more training and equipment for fighting fire in the brush and off the road. The same may be said for the rural fire services in becoming more familiar with urban firefighting methods.

23. Humans can survive fire in dense rural-urban fuel mixes provided shelter is immediately available that will resist fire for a few minutes until the rural fire passes.

24. Effective command with supporting staff was established early in the Coyote Fire emergency and was maintained throughout the fire.

25. The dispatching system on the Coyote Fire is a good example of a flexible system that can expand and shift from district, to forest, to zone, to region, as the problem enlarges.

26. The Coyote Fire started from a single ignition which was discovered quickly and fire forces responded with an all-out initial attack. Yet the single ignition escaped and spread to become a project fire. Obviously if nuclear warheads were detonated under similiar conditions of fuel and weather, numerous fires would start and spread to form large fires of unmanageable proportions. Control would have to be selective and the objectives would be to protect lives and specific key resources and improvements.

27. The threat to urban areas from uncontrolled wildland fires is substantial when conditions of fuel approximate those experienced in the Coyote Fire.

V. RECOMMENDATIONS

These recommendations are concerned with problems, that if solved, would increase effectiveness and contribute toward a nationally coordinated fire system.

1. Encourage the establishment of fire control mutual aid arrangements, including strengthening of existing ones, to cover broad geographical fire problem areas in the United States.

2. Encourage and support joint agency training for a large fire emergency. Joint training is the key to effective action.

3. Include law enforcement departments and the military in joint training.

4. Further integrate air attack with fixed-wing aircraft and helicopters into plans for disaster fire suppression. Air attack alone can protect certain types of key structures.

5. Encourage and promote training and equipping of small fire brigades composed of residents. Plan to integrate them into the large fire suppression picture.

6. Plan for integrating improved procedures for scouting and fire intelligence into command and mutual aid arrangements. The infrared fire mapping scanner is an example of this advanced equipment.

7. Consider using or adapting for multi-agency training in large fire emergencies, the organization and command procedures developed over the years by the Forest Service.

8. Promote, as necessary and proper, means for fuel treatment for hazard reduction to make our urban and rural areas less vulnerable to fire.

9. Encourage and promote the use of fire weather and fire behavior forecast teams on all large fire emergencies.

10. Encourage increased training in rural fire suppression for urban fire crews, and urban fire suppression for rural crews, located in urban-rural fringe areas.

11. Conduct studies of the proper balance between access roads, fuel treatment, auxillary water sources, prevention, manpower, and machinery for fire control.

12. Coordinate Civil Defense and fire services so that fire defense utilizes the capabilities of both during disasters.

13. Inventory available personnel that are working in organized labor, and have the stamina and training to work effectively in fire control.

14. Use the Coyote Fire as a case example for training fire staff and Command for Nuclear Fire Defense.

VI. APPENDIX

Appendix A. --Conduct of Study

B. --Individuals Interviewed

C. --Individual Fire Report

D. --Fire Weather Observations for September 23 and 24, 1964 on the Coyote Fire

E. --Disaster Abatement Agreement

F. --Fire Organization, Coyote Fire

G. --General Headquarters (GHQ) Organization, Coyote Fire

H. --Selected Fire Weather Forecasts and Fire Behavior Forecasts, Coyote Fire

I. --Documents and Records on File

APPENDIX A

CONDUCT OF STUDY

APPENDIX A

CONDUCT OF STUDY

The study was conducted by a single analyst that combined a complete review of the pertinent file material with a series of interviews with key individuals, and a visit to the site of the fire. Theodore G. Storey, Fire Analyst, with OCD Project 229 stationed at the Forest Fire Laboratory in Riverside, California was assigned to make the study by W. R. Moore, Project Chief, in Washington, D. C. about April 1, 1965.

Record material from the Forest Service Regional Office in San Francisco, the Los Padres Supervisor's Office in Santa Barbara, the Forest Fire Laboratory in Riverside, and personal files of individuals working on the fire were made available for the study, as well as portions of personal files of some of the individuals that were interviewed.

The Coyote Fire is famous in recent California fire history and as a result is well-documented in reports and accounts of the fire action prepared by agencies involved and other interested individuals. The fire received extensive coverage in national magazines, and at the time received nationwide press coverage when the city of Santa Barbara and smaller communities were threatened along a broad front.

Most of the material reviewed by the analyst is in good general agreement concerning direct action on the fire, time sequence of events, and utilization of suppression forces. The review and analysis of available knowledge that is not always available through interviews, especially when a period of time has passed since the actual fire experience. Interviews provide impressions of past action and reveal certain parts of the overall fire suppression job.

As a direct result of the Coyote Fire and the Santa Rosa fires, the California State Senate Fact Finding Committee on Natural Resources convened a hearing in Santa Barbara October 15, 1964. The analyst attended this hearing and information from the transcript was utilized for the present report. The Senate Committee Report and other pertinent reports used are referenced in Appendix P, Documents and Records on File.

The analyst also studied and reported on the Santa Rosa fires currently for Project 229. These fires were still burning when the Coyote Fire started. Each had an influence on the other through their drain on equipment and manpower reserves.

APPENDIX B

INDIVIDUALS INTERVIEWED

APPENDIX B

INDIVIDUALS INTERVIEWED

Name	Position During Fire	Regular Position
C. M. Countryman	Member, Fatality Investigation Team, Coyote Fire	Project Leader, Fire Behavior, Fire Lab. PSWF&RES, Riverside.
M. J. Schroeder	Fire Behavior Officer, Coyote Fire	Project Leader, Fire Meteorology, Fire Lab. PSWF&RES, Riverside.
H. W. Mansfield	Air Attack Boss, Coyote Fire	Assistant Fire Control Officer, Los Padres N.F. Santa Barbara
W. H. Hansen	Fire Boss, Coyote Fire	Forest Supervisor, Los Padres N.F., Santa Barbara
C. W. Hickerson	Zone Fire Boss, Coyote Fire	Fire Control Officer, Los Padres N.F., Santa Barbara
C. Ulrey	Calif. Disaster Office Representative, Fire Boss Staff, Coyote Fire	Field Representative, California Disaster Office San Bernardino

APPENDIX C

INDIVIDUAL FIRE REPORT

USDA-FOREST SERVICE

INDIVIDUAL FIRE REPORT

RANGER FIRE NO.	NAME OF FIRE
9	Coyote
REGION FIRE NO.	**SIZE CLASS**
	E

MANDATORY ITEMS: Class A- Items 1-39 Class B- Items 1-49b Class C, D and E- Items 1-53

This fire is being reported by the State as its fire. *(Check one)* [X] Yes [ ] No

1. State [2-3]	2. County	3. Forest [4-5]	4. Ranger District [6-7]	or LUP [6-7]
California 4	Santa Barbara	Los Padres 7	Santa Barbara 54	

5. Supervisor Fire No. [8-10]	6. Month [11]	Day [12-13]	Year [14]	7. Size Class [15]	8. General cause [16-17]
29	9	22	4	E 5	Resident 68

9. Specific cause [18-19]	Other (Unknown) 8		27. Burning index	12	Buildup index 514 [54-57] 1214
10. Class of people [20]	Local Perm 5		28. Character of fire on arrival [58]	Spotting 4	
11. Fire started on [21]	Other Lands inside Forest Service Protection Boundary 2		29. Topography - vicinity of origin [59]	Lower 1/3 of Slope 5	
	D. S.	DATE / HOUR	ELAPSED TIME Hours / Min.		
12. Origin *(Check one)*	[ ] Known [X] Guess	9/22 1357	[22-23] 13 x	30. Slope [60]	20% 2
. Discovered (Item 13 minus 12)		9/22 1401	[24-25] [26-27] 4	31. Aspect [61]	S 2
14. Reported (Item 14 minus 13)		9/22 1403	[28] [29-30] 2	32. Elevation [62]	790' 1
15. Departed		9/22 1404		33. Cover type - vicinity of origin [63-64]	Brush on Non-Timber Soil 21
16. First attack (Item 16 minus 13)		9/22 1406	[31-32] [33-34] 5	34. Specific fuel - point of origin [65]	Grass and Stubble 0
17. Travel time (Item 16 minus 15)			[35] [36-37] 2	35. Fuel type prevailing on area - origin to attack [66-67]	Moderate Chamise and Chaparral 23
18. First reinforcements (Item 18 minus 16)		9/22 1416	[38] [39-40] 10	36. Perimeter increase in chains per hour - discovery to attack [68-70]	Unknown x
19. Fire controlled (Item 19 minus 16)		10/1 1800	[41-43] 220	37. Forward rate of spread in chains per hour - discovery to attack [71-72]	3 Chains - 5 Minutes 36
20. Fire mopped up (Item 20 minus 19)		10/10 1800	[44-46] 216	38. Map record: Scale: _____ inches = 1 mile	See Attached
21. Fire out		10/28 1600			
. Discovered by (Class)	Location		[47]		
	Other (Resident) Scene		9		
23. Reported to (Class)	Location		[48]		
	Suppression Crew Mt. Drive Station		2		
24. First attack (Kind)	Amount		[49-50]		
	Ground Tankers 5		35		
25. First reinforcements (Kind)	Amount		[51-52]		
	Ground Tankers 3		33		
26. Hour control zone			[53]		
	15 Minutes		1		

39. Location description

a. Township 4N	[73-75] 41
b. Range 27W	[76-78] 272
c. Section 1	[79-80] 1
d. Mer. SBBM	

Alternate description: Use for land not covered by GLO survey

e. Latitude	[73-76]
f. Longitude	[77-80]

40. Cover type prevailing on burned area [18-19]	Brush 2	46. Man-hours to control [38-41]	253,200 253200
41. Area when discovered [20-21]	.1 0	47. Mopup in percent of total effort [42-43]	25,380 9
42. Area when attacked [22-24]	.5 0	48. Percent of perimeter worked by:	
43. Area when controlled [25-29]	67,000 67000	a. Ground tankers and pumpers [44]	198 - 1685 1
44. Perimeter in chains when controlled [30-33]	(12,800 Tot Chns) 9999	b. Ground machines [45]	92 - 520 0
45. Maximum number of line workers [34-37]	2570 2570	c. Aerial attack [46]	588,200 - 6400 5

5100-29 (1/60)

SUMMARY OF FIRE DAMAGE Class B fires: Items 49a and 49b mandatory. Class C and larger: Items 49a through 53 mandatory.	N.F. LANDS (1)		OTHER LANDS INSIDE F.S. PROTECTION BOUNDARY (2)	
	Acres or Dollars	Code Column	Acres or Dollars	Code Column
49. Acres burned				
a. Noncommercial forest land 63,000		[47-51] 46000		[52-56] 17000
b. Commercial forest land		[57-61]		[62-66]
c. Seedlings and saplings destroyed				
50. Volume (MBM) of timber destroyed (convert cords to MBM)		[67-71]		[72-76]
51. Value of timber damaged or destroyed				
a. Merchantable timber				
b. Seedlings and saplings				
c. Other timber				
d. Total timber damage (a to c, incl.)		[18-22]		[23-27]
52. Value of other damage (nontimber)				
a. Watershed $14,476,151.00	9,231,651	[28-32] 92317	5,244,500	[33-36] 9999
b. Recreation 12,000.00	9,000	[37-40] 90	3,000	[41-44] 30
c. Range and wildlife 10,000.00	7,000		3,000	
d. Improvements 2,765,200.00	171,600	[45-48] 1716	2,593,600	[49-52] 9999
e. Other nontimber				
f. Total nontimber damage (a to e, incl.) 17,263,351.00	9,419,251	[53-57] 94193	7,844,100	[58-62] 78441
53. GRAND TOTAL DAMAGE (Items 51d and 52f) 17,263,351.00		[63-67] 94193		[68-72] 99999

Remarks:

cc-State

Item 46 - This is not a coded figure. (Also #53 (63-67) not coded, Use uncoded $'s.

48-b - 2900 Chains Secondary Line Constructed by Tractors.

48-c - Air Attack on Key Portions of Lines to Insure Control 80 Miles of Perimeter.

49-a - 4000 Acres Outside National Forest Protection Boundary.
(Watershed Damage - $1,234,000.)

	DATE	SIGNATURE	TITLE
SUBMITTED →	12/21/64	/s/ Warren Barnes	District Ranger (or Acting)
APPROVED →	1/14/65	/s/ William H. Hansen	Forest Supervisor (or Acting)

GPO 884390

APPENDIX D

FIRE WEATHER OBSERVATIONS FOR

September 23 and 24, 1964 on the Coyote Fire

FIRE WEATHER OBSERVATIONS

Fire Coyote Date 9/23/64

Location	Elev	Time	Temp		RH	DP	Wind		Remarks
			Dry	Wet			Dir.	Sp.	
Westmont Camp	700	0400	65	55	53		N	1-2	
" " "	700	0435	68	55	43	25	N	2	
" " "	700	0708	69	55	40	44			
Power line & Hot Springs Canyon	115	1000	87	63	24		S	4	Fire beyond ridge
Westmont Camp	700	1030	88	62	21		WSW	6-8	
South Slope near top of Ridge	3400	1110	89	59	14		SE	5	
Water Tank on ridge	3500	1145	81	55.5	17		WSW	6	
Westmont Camp	700	1331	86	65	31		SE	3	
" " "	700	1430					SSE	0-2	
" " "	700	1647	87	66	32		SW	4	
" " "	700	1925	88	60	16		NNW	8-10	G25 5 min later
West of fire	Ridge	1930	74	52	20		NNE	25-35	G40
Santa Ana at	700	1940	80	61	28	46	NE	16-20	G30
Westmont Camp			90						
Westmont Camp	700	1954	83	61	27		SE	4	
" " "	700	1955	83	61	27		SE	4	St. NE winds abv.

FIRE WEATHER OBSERVATIONS

Fire Coyote Date 9/24/64

Location	Elev	Time	Temp Dry	Temp Wet	RH	DP	Wind Dir.	Wind Sp.	Remarks
Westmont Camp	700	0234	92	60	12	31	N	16	G 20
" " "	700	0515	91	60	13		N	6-8	G 12
" " "	700	0545	74	62	51		ESE	4-6	
Backfire "	1300	0640	86	59	17	36	NE		
" " "	1300	0647	88	61	19	40			
" " "	1300	0652	91	61	15	37			
" " "	1300	0658	89	60	15	36			
Saddle		0715	75	57.5	33	44	WSW	6	
Backfire		0735	71	59	49	51			
Saddle		0750	68	59	59	53			
Backfire		0805	70	60	56	54			
" "	1300	0830	72	60	50	52	NNE	6	
Beyond Saddle	1400	0910	90	62	18	41	VAR	6-8	
" "		0930	79	60	32	46			
Backfire		1120	87.5	63	24	46			
Westmont Camp	700	1418	84	64	32		V	1-2	Ac
" " "	700	1615	84	62	27		W	5	Acc SE-s TWRG Cu
La Cumbre Pk. L. O.	3750	1630	75	56	27		SW	12	Gusts to 18 High E winds
Gibralter Rd.	3900	1725	82	59	24				
La Cumbre Pk. L. O.	3750	1815	78	57	27	41	SE	12	
Westmont Camp	700	1850	75		45		V	1-2	Ac Cl
La Cumbre Pk. L. O.	3750	2200	69	54	38	43	W	2-3	
" " "	3750	2300	71	55	37	43	Calm		

APPENDIX E

DISASTER ABATEMENT AGREEMENT

DISASTER ABATEMENT

South Coast of Santa Barbara County

Revised 1961 at joint meeting with:

S. B. Co. Fire Dept. - V. A. Wadleigh, Chief
City of S. B. Fire Dept. - Roy Tenney, Chief
Montecito Fire District - Herb Ensign, Chief
Carpinteria Fire District - Frank Floyd, Chief
U. S. Forest Service - Warren Barnes, Chief Ranger

I. Statement of Need

The fire situation in the South coast of Santa Barbara County area, though not unique contains several factors that make the problem far from simple. These are:

1. The highly inflammable nature of the vegetation combined with critical summer fire weather in the areas immediately adjacent to the intensively developed centers of population on the coastal plain along the Santa Barbara front.

2. The situation is further aggravated by the continual extension of structural and other developments into areas completely surrounded by the highly inflammable vegetation.

3. There are five separate fire suppression agencies each with definitely assigned territories of responsibility but with these territories so situated that almost any wild fire in one zone immediately threatens the territory of one or more other agency.

4. The close association of large numbers of people and valuable improvements with serious fire threat requires the full utilization and coordination of all available resources within the area in order to promptly abate any disaster resulting from an uncontrolled fire.

The situation at Ojai in 1948 and the 1955 Refugio Fire are all too forceful examples of what can occur here. This plan, then, is designed to combat our problem. It will contain procedures for correlating the fire suppression skills, equipment and other resources of all fire suppression agencies and other facilitating groups to the end that, in case of serious fire, the least possible loss to tangible as well as intangible values will accrue and hardship to local residents shall be held to a minimum.

II. Agencies Involved and Responsibilities of Each

A. Primary (Firefighting)

1. U. S. Forest Service

The suppression of all uncontrolled watershed fires on all land within the boundary of Los Padres National Forest.

2. Santa Barbara County Fire Department

Fire suppression on all lands, property and improvements

outside of incorporated cities, incorporated fire districts, and the National Forest. Improvements within certain fire districts within National Forest.

3. Santa Barbara City Fire Department

Fire suppression on all lands, property and improvements within the city limits of Santa Barbara.

4. Montecito Fire Department

Fire suppression on all lands, property and improvements within the boundaries of the Montecito Fire District.

5. Carpinteria Fire District

Fire suppression on all lands, property and improvements within the boundaries of the Carpinteria Fire District.

B. Facilitation Agencies
County Sheriff's Department
California Highway Patrol
Santa Barbara City Police Department
American Red Cross
District and City Water Departments
County Health Departments
Utility Companies, i.e., light, gas and telephone
Transportation Companies
Employment Services
Newspaper and Radio Stations

All the above facilitating agencies are responsible for assisting within their respective fields and limits of their authority as their assistance is needed and requested by fire control agencies.

III. Plan of Action

A. Central Board of Strategy

1. When a fire burns or threatens to burn on land or improvements that are the responsibility of more than one agency to protect, a Central Board of Strategy will be established to meet continuously at an appropriate location until the fire is out.

2. The Board of Strategy shall be composed of an authoritative representative of each agency that is responsible for the fire protection in the particular area involved in any given fire. Fire agencies called in for assistance shall serve on the Board of Strategy in an advisory capacity.

3. Functions of the board. The board shall plan and cause to be executed all strategy for controlling the fire and abating disaster. No agency shall act independently of the board on overall strategy. The Board of Strategy shall have full control and command of fire-fighting forces and operations. Except that this does not prohibit a single agency from taking temporary emergency action in order to save life or improvements within its area of assigned responsibility.

B. Part to be played by facilitating agencies on Central Board of Strategy. It shall be the duty and privilege of the Board of Strategy to call on non-firefighting groups or individuals such as Red Cross, State Highway Patrol, etc., to assist within their respective fields and limits of their authority in the control of the fire and/or the abatement of the disaster. When the various facilitating groups are called for assistance it is the responsibility of the Central Board of Strategy to invite a responsible individual from each group to sit in, in an advisory and facilitating capacity.

C. Communication

It shall be the responsibility of each member or facilitator sitting on the Central Board of Strategy to establish reasonable and practical continuous communication facilities at the meeting place of the Central Board of Strategy so that decisions of the Board may be placed into effect without delay.

D. Report of Fire

When a report of a fire is received by a fire agency regardless of time of day or night and there is the least question as to the fire location being on that agencies area of responsibility, the agency receiving the report shall immediately relay the report to the agency on whose area the fire may be on or near.

There should be no delay occasioned by an attempt to confirm the fire and may involve reporting the fire to two or more agencies.

E. Mutual Aid

Prior to the establishment of the Board of Strategy and under conditions conducive to a disaster fire, a system of initial attack mutual aid shall be in effect. Such mutual aid may be initiated with or without request from the agency responsible and no charge back to the responsible agency shall be made.

Areas on which initial attack mutual aid by each agency is to be in effect is designated on attached maps.

Mutual aid other than that outlined above shall be covered by co-op agreement and cleared through the County Fire Coordinator when necessary.

APPENDIX F

FIRE ORGANIZATION, COYOTE FIRE

Date 9/23/64
Shift Day
6:00 AM - 6:00 PM

FIRE ORGANIZATION

Fire Boss Hickerson

Plans	
Plans Chief	Maule
Maps & Records	Miller
Intelligence	Heikes
Public Information	Parkinson
Fire Behavior	Revely
Safety Officer	Lord
Coordinator	Barnes

Service	
Service Chief	Russell
Air Service	Mansfield
Equip. Officer	Austin
Camp Officer	Netland
Supply Officer	Maitland
Communications Officer	Pogue

Finance	
Finance Chief	Burke
Time Officer	Millington
Compensation Officer	Baker
Obligation Officer	Burke
Claims Officer	Kinyon

Line Boss Lundgren

Div. Boss I Biedeback

Sec. Boss A	Sec. Boss B	Sec. Boss C
Thomas	White	Boggs
Men	Men	Men
50 Porterville	50 Port.	50
Pumpers	Pumpers	Pumpers
2	4	
Tractors	Tractors	Tractors
		2

Div. Boss II Marquez

Sec. Boss D	Sec. Boss E	Sec. Boss F
Cochran	Del John	Darr
Men	Men	Men
75 Port.	50 Port.	25 Port.
Pumpers	Pumpers	Pumpers
Tractors	Tractors	Tractors
1		6

Div. Boss III City-Fire Dist.

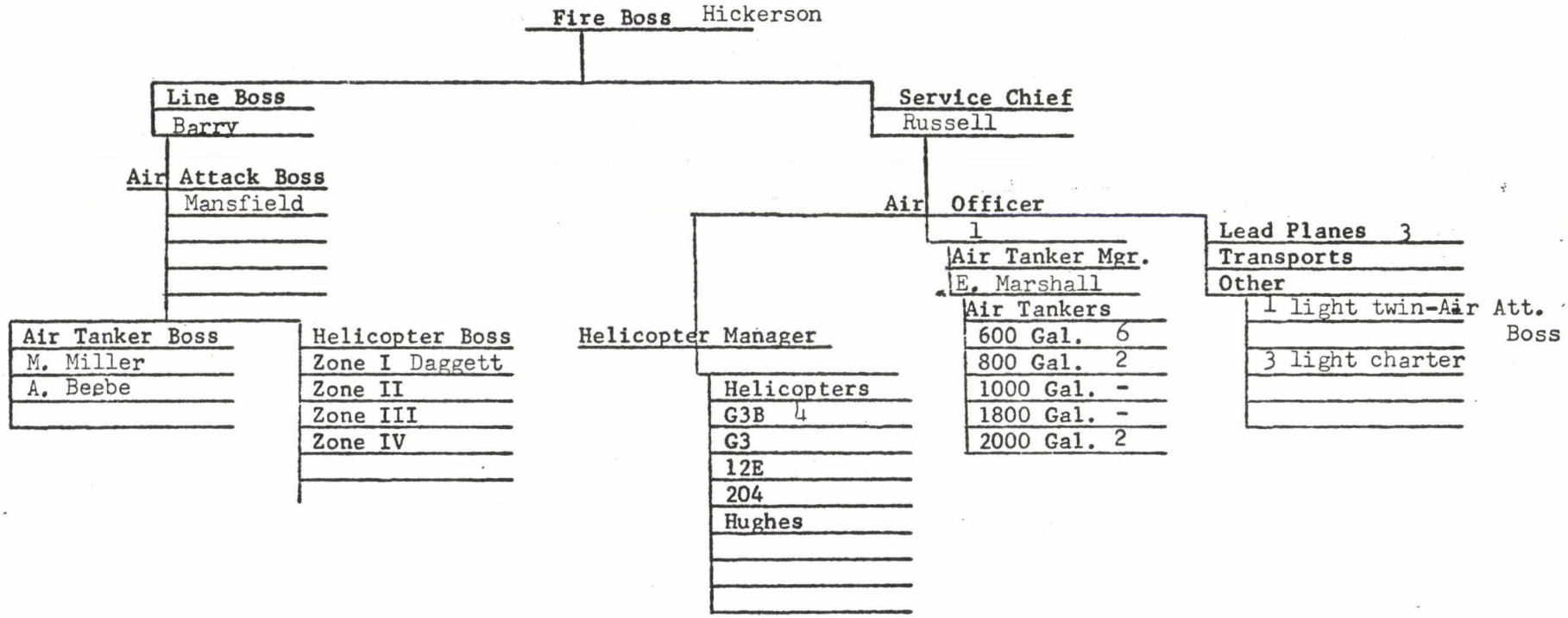
Sec. Boss G	Sec. Boss	Sec. Boss
Shaffer		
Men	Men	Men
37 Inmates		
Pumpers	Pumpers	Pumpers
4		
Tractors	Tractors	Tractors

Date 9/23/64

Shift Day
0730 - 1900

AIR ORGANIZATION

COYOTE FIRE



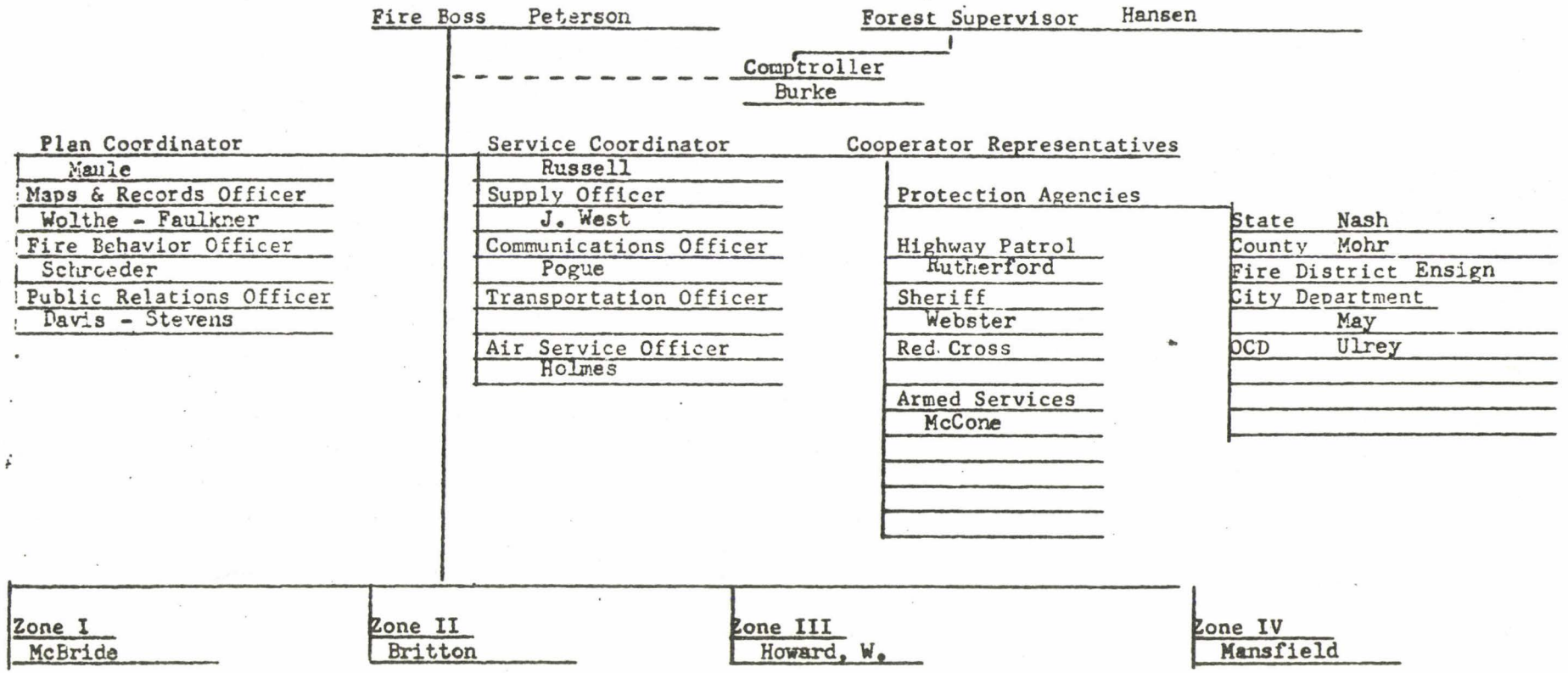
APPENDIX G

GENERAL HEADQUARTERS (GHQ) ORGANIZATION CHART, COYOTE FIRE

9/27/64

GHQ ORGANIZATION

COYOTE FIRE



ZONE FIRE ORGANIZATION

ZONE NO. I

Date 9/27/64
Shift Day
6:00 AM to 6:00 PM

Zone Fire Boss McBride

Plans	Service	Finance
Plans Chief Dalen	Service Chief Blomstrom	Finance Chief Baker
Maps & Records Roether	Air Service	Time Officer
Intelligence	Equip. Officer Austin	Compensation Officer Worthington
Public Information	Camp Officer	Obligation Officer
Fire Behavior Decker	Supply Officer	Claims Officer Eckmeyer
Safety Officer Meik	Communications Officer	

Line Boss Biddison

Div. Boss II Lundgren			Div. Boss III Nelson			Div. Boss IV Petty		
Sec. Boss Mills	Sec. Boss Tonneson	Sec. Boss	Sec. Boss Boggs	Sec. Boss Shafer	Sec. Boss	Sec. Boss Criswell	Sec. Boss Benedictson	Sec. Boss
Men 25	Men 25	Men	Men 78	Men 26	Men	Men 42	Men 105	Men 105
Pumpers 7	Pumpers	Pumpers	Pumpers 4	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers
Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors 10	Tractors	Tractors 14

ZONE FIRE ORGANIZATION
ZONE NO. II

Date 9/27/64
Shift Day
6:00 AM to 6:00 PM

Zone Fire Boss Britton

Plans	Service	Finance
Plans Chief Janes	Service Chief Lewis	Finance Chief Lundeen
Maps & Records Harrell	Air Service Daggett	Time Officer Cinicero
Intelligence	Equip. Officer M. Roberts	Compensation Officer
Public Information	Camp Officer Fuqua	Obligation Officer
Fire Behavior Lust	Supply Officer	Claims Officer
Safety Officer Winters	Communications Officer	

Line Boss Clark

Div. Boss I Thomas - Vinson			Div. Boss II Hinton			Div. Boss III David		
Sec. Boss Priest	Sec. Boss	Sec. Boss	Sec. Boss Burrel	Sec. Boss	Sec. Boss	Sec. Boss Ward	Sec. Boss Kendall	Sec. Boss Parks
Men 80	Men 15	Men	Men 105	Men	Men	Men 105	Men 50	Men 50
Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers
Tractors 2	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors 2	Tractors

ZONE FIRE ORGANIZATION

ZONE NO. III

Date 9/27/64
Shift Day
6:00 AM to 6:00 PM

Zone Fire Boss Howard

Plans		Service		Finance	
Plans Chief	Biddison	Service Chief	Blodgett	Finance Chief	Davies
Maps & Records	Vance	Air Service	Ratledge	Time Officer	Ferris
Intelligence	Nunn	Equip. Officer	Adams	Compensation Officer	Dinwiddie
Public Information		Camp Officer	McAllister	Obligation Officer	
Fire Behavior	Hardy	Supply Officer		Claims Officer	
Safety Officer	Warnock	Communications Officer			

Line Boss Garson

Div. Boss			Div. Boss			Div. Boss		
Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss
Kennedy	Robinson	Scharff						
Men	Men	Men	Men	Men	Men	Men	Men	Men
70 Navy	25	63						
Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers
3								
Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors

ZONE FIRE ORGANIZATION
ZONE NO. IV

Date 9/27/64
Shift Day
6:00 AM to 6:00 PM

Zone Fire Boss Mansfield

Plans	Service	Finance
Plans Chief Turner	Service Chief Downing	Finance Chief Helmar
Maps & Records Dzurissin	Air Service Watson	Time Officer Porter
Intelligence	Equip. Officer Johnson	Compensation Officer
Public Information	Camp Officer	Obligation Officer
Fire Behavior Mutch	Supply Officer Houseman	Claims Officer
Safety Officer Coburn	Communications Officer Hayes	

Line Boss Berry

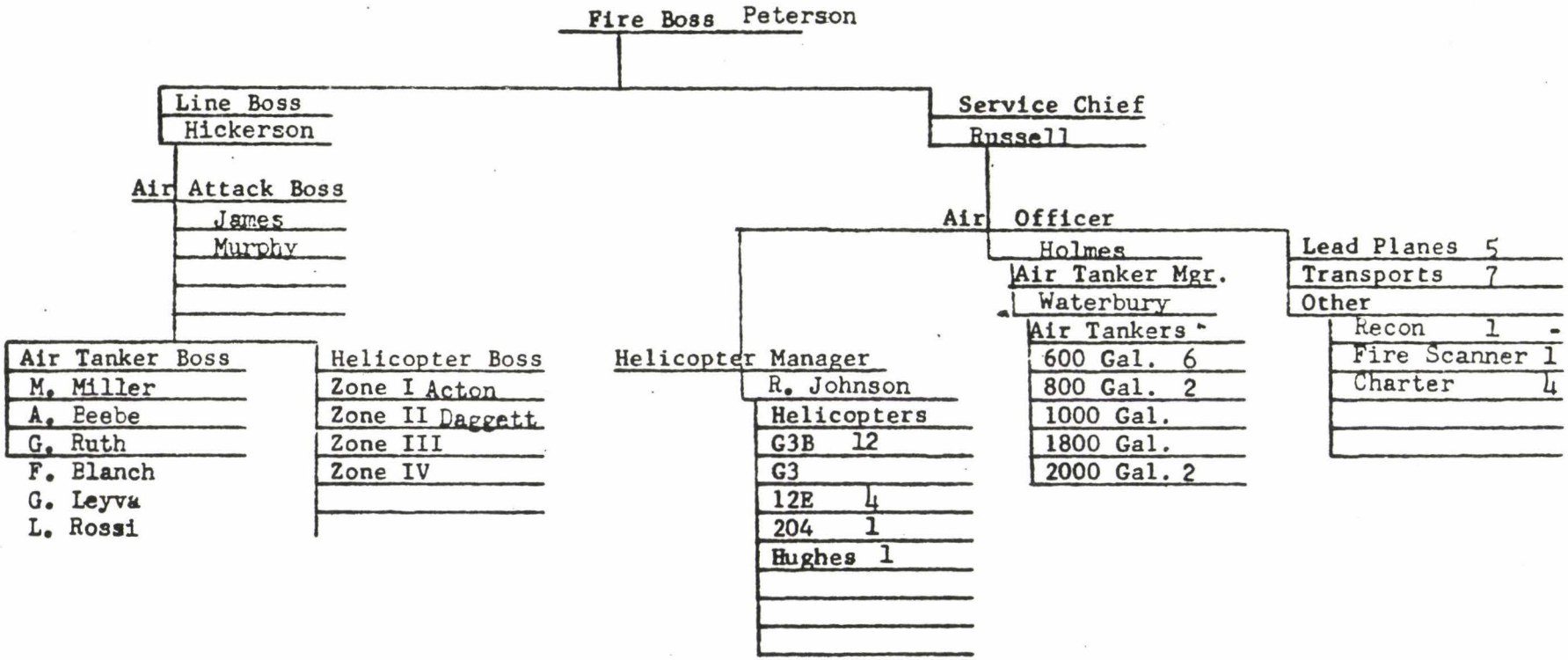
Div. Boss I — Tracy			Div. Boss II — Slaughter			Div. Boss		
Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss	Sec. Boss
Fitzgerald	Jordan							
Men	Men	Men	Men	Men	Men	Men	Men	Men
50 Navy	57							
Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers	Pumpers
	4							
Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors	Tractors
2				14				

Date 9/27/64

Shift Day
6:00 AM to 6:00 PM

AIR ORGANIZATION

COYOTE FIRE



APPENDIX H

SELECTED FIRE WEATHER FORECASTS AND FIRE BEHAVIOR FORECASTS, COYOTE FIRE

Southern California Fire Weather Mobile Unit

Forecast For Coyote Fire, Los Padres National Forest

Forecast No. 1, Wednesday, September 23, 1964

General: High pressure western U.S. surface and aloft continues to dominate weather picture.

Temperatures: Slightly warmer than yesterday. Maximum in middle 80s.

Humidity: From a high of about 50 before daybreak humidity will drop during day to 20 to 25 percent.

Wind: Over higher ridges will continue mostly from northeast to east 8 to 15 mph. In lower fire area variable direction in morning 2 to 6 mph, becoming mostly SW 6 to 10.

Stability: Air will continue fairly stable, if anything slightly more stable than yesterday.

George Ellis and Don Lust
Fire Weather Forecasters

Fire Behavior Forecast No. 1, Day Shift, September 23, 1964

General: Since northeast winds are expected to affect only the ridge top and are not expected to get down into the fire area, and the air mass will be comparatively stable, no unusual fire activity is expected today.

Sectors A, B, D & G- Fire spread will be responding primarily to topography during the forenoon, and will be aided in its upslope spread by the south to southwest winds in the afternoon. Greatest pressures will be on sectors E and G. Where fire burns hot enough to get burning embers up to 5000 feet the embers will be carried to the west by strong easterly winds above that level.

Outlook: From present indications we do not expect a repeat of last night's winds, but since the surfacing of northeast winds during the evening hours is characteristic of Santa Ana situations we must recognize that it is at least a remote possibility.

Mark J. Schroeder
Fire Behavior Officer
0530 PDT September 23, 1964

Forecast No. 2, Night of Wednesday-Thursday, September 23-24, 1964

General: Strong upper-level high-pressure area continues to dominate weather, bring abnormally high temperatures and low humidities to the fire area.

Temperature: Lowering after sunset to a minimum of 65 in camp and to about 70 at the ridge top.

Humidity: Rising to a high of 50% in camp and low levels, and a high of 35% along ridge tops.

Winds: Over ridges, East to Northeast 17 to 24. Downslope winds 3 to 7 beginning by 10 pm. In Santa Ynez Valley downvalley mostly easterly 3 to 7. While the probability of a recurrence of the strong E winds that blew last night for a while is slight, the possibility cannot be completely ruled out tonight. Personnel should be aware of this possibility.

Outlook: Slightly higher temps Thursday with the high in the low 90's and Humidity at camp level slightly lower in 15-20% range and little change along ridges. Continued East to Northeast winds in the higher levels.

George Ellis, Donald Lust
Fire Weather Forecasters

Fire Behavior Forecast No. 2, Night Shift, September 23, 1964

General: Because of the dense and dry fuels and steep topography, rather hot runs can be expected thru the night, particularly at higher levels.

Sectors A and east side: With light downslope winds fire will gradually eat away fuels to west along sector A and to the east along east side in short upslope runs which become hotter above about 2000 feet, the top of the night time inversion.

Sectors F and G: In the Santa Ynez drainage where fuels are especially heavy short but hot runs can be expected. With easterly drainage winds in this area spread along sector F will be more rapid.

Caution: Strong northeasterly winds still exist aloft although the layer has been raising since morning. The odds are against these winds surfacing like they did last night, and driving the fire into residential areas, but there is something like a 10% chance that this could happen.

Outlook: Little change in fire activity Thursday except that downslope winds in the afternoon on north-facing slopes are likely.

Mark J. Schroeder
Fire Behavior Officer
1558 PDT September 23, 1964

AMENDED FORECAST FOR NIGHT SHIFT OF 9/23/64

Sequence of events evening of 23 September relative to surfacing of Santa Ana winds on Coyote Fire:

Although the forecast for the night shift indicated a small probability of the wind surfacing, John Dell was sent to ridge to watch for indications.

Dell recorded north-northeast winds of 20 mph with gusts to 35. Temperature was 86 and relative humidity 14. This report was sent to me by radio at 1915 PDT. The time of the observation was 1900.

At 1930 I notified the Fire Boss that the Santa Ana winds would surface in a manner similar to the previous night. He got on the radio immediately to notify men on the line of this and asked them to take precautions.

At 1940 the northeast winds were felt at the fire camp. Temperatures rose abruptly and humidity dropped as the winds picked up to 16-20 mph with gusts to 30. These conditions continued thru the night until about 0545.

Mark J. Schroeder
Fire Behavior Officer

Forecast No. 3, Thursday, September 24, 1964

General: Santa Ana condition has intensified and shows no sign of weakening today.

Temperature: Slightly warmer today. High temps middle 90s all levels.

Humidity: Very low, 10 to 15 percent in morning probably improving slightly to 15 to 25 in afternoon.

Wind: Continued strong Santa Ana winds. Mostly NE to E 12 to 20 exposed low levels and 15 to 35 over exposed ridges, gusty all levels. Some decrease in low-level winds in PM, direction becoming variable, mostly easterly, 0 to 15 mph. Wind continuing strong over high ridges.

Cautions: Air has become unstable allowing stronger vertical motion encouraging gusty erratic winds and strong convection.

Outlook: No relief in sight as far as large-scale weather pattern goes. Probably less windy tomorrow.

G. Ellis and D. V. Lust
Fire Weather Forecasters

Fire Behavior Forecast, No. 3, Day Shift, September 24, 1964

General: Strong Santa Ana conditions will continue at high levels but will weaken at low levels during day. Fuels are very dry and dense, and hot runs can be expected wherever favored by winds or topography. Atmospheric instability will favor the development of large convection columns, spotting, and firewhirls.

South Side: Santa Ana winds should lift during day allowing some onshore and upslope winds and permit control action.

Santa Ynez Drainage: Santa Ana winds will decrease in lower levels during day but continue from northeast and east direction at high levels. This should decrease fire activity on west side except by button-hooking and running upslope. It will also permit fire to run rapidly and hot up north side of drainage wherever it crosses bottom. Hot runs can be expected on east side. At higher levels where Santa Ana winds remain strong continued fast spread to west can be expected.

West Side of Santa Barbara Front: Decreased fire activity at low levels, westerly spread at high levels.

East Side of Santa Barbara Front: Hot upslope runs aided by upslope winds and possible lee eddies in lower levels, Santa Ana winds opposing eastward spread at higher levels.

Cautions: All should be aware by now that this is a critical fire situation and should take necessary precautions.

Outlook: Santa Ana winds are again likely to surface tonight.

Mark J. Schroeder
Fire Behavior Officer
0400 PDT September 24, 1964

Forecast No. 4, Night of Thursday-Friday, September 24-25, 1964

General: Offshore gradient is weakening. Considerable moisture is coming into area from upper low over Arizona. Showers and thunderstorms are occurring in San Diego and San Bernardino Counties.

Temperature: Continued rather warm, but not as warm low levels as last night. Min Temp Westmont College high 70s and about same at 3500 ft. level.

Humidity: Except for possible periods of downslope winds during night when humidity would lower to 15-20 percent at low levels, humidity will remain in 40 to 60 percent range low levels; at 3500 foot level humidities will remain rather low, about 18 to 25 percent.

Wind: Decreasing easterly wind over ridges, mostly 7 to 15 mph and becoming more variable in direction. While there is still a possibility of strong northeast winds surfacing at low levels as they did last night, the chances are considerably less, and if this does occur the period of wind will be less and the winds not as strong. Night-time drainage winds in canyons poorly developed due to cloud and smoke cover.

Notes: Considerable increase in moisture aloft. Air continues quite unstable.

APPENDIX I

DOCUMENTS AND RECORDS ON FILE

APPENDIX I

DOCUMENTS AND RECORDS ON FILE
(National Fire Coordination Study)

1. "Fire Problems of California." Transcript of Hearing of the Senate Fact Finding Committee on Natural Resources, Fred S. Farr, Chairman. Held in Santa Barbara, October 15, 1964. 146pp.

2. "Administrative Fire Analysis--Coyote Fire" September 22-October 1, 1964. Los Padres National Forest, Santa Barbara, California, March 30, 1965. 108 pp, App.

3. "Wildland Development Fire Protection Master Plan." A Report of the Technical Agencies Subcommittee on Wildland Fire Protection to the City-County Relations Committee, Southern California Regional Association of County Supervisors. Preliminary Draft. October 9, 1964. 25pp.

4. Report of Committee on "Study of Controlled Burning Program as Fire Prevention Measure," Santa Barbara, California, December 3, 1964. Committee appointed by Santa Barbara County Board of Supervisors. 13pp.

5. "General Review and Information for the Office of Civilian Defense" for Coyote Fire September 22-October 1, 1964, by Los Padres National Forest. May 18, 1965. 3pp. plus attachment.

6. "Fire Behavior Coyote Fire." Forest Fire Laboratory, Riverside, U.S. Forest Service. Rough Draft. October 9, 1964. 30 pp. (weather data and fire weather and fire behavior forecasts).

7. "Narrative Fire Report, 1964 Fire Season, Region 5." U.S. Forest Service, San Francisco, December 16, 1964. 20pp.

8. "Recommendations, Regional Fire Analysis Committee R-5, 1964 Season." U.S. Forest Service, San Francisco. May 17, 1965. 8 pp. (stemming primarily from Coyote Fire.)

9. "Comments on Analysis of Coyote Fire." Memorandum from M.S. Lowden to Deputy Chief of the Forest Service. April 1, 1965. 6 pp.

10. "Dispatching Systems." U. S. Forest Service and California Division of Forestry.

11. "Sample Computation of Control Force Needs." Coyote Fire - September 22, 1964.

12. "Logistics and Action Timing - Coyote Fire." Notes prepared to T. G. Storey.

13. "Sample Communication Diagram and Description." Coyote Fire, Friday, September 25, Saturday, September 26.

14. "Newspaper Accounts of Coyote Fire."
Santa Rosa Press-Democrat: 9/23/64
San Francisco Chronicle: 9/23, 24, 25, 26/64.

INSTRUCTOR'S LESSON PLAN

SUBJECT: THE STUDY OF LARGE FIRES	INSTRUCTOR: Frank Lewis
TITLE OF LESSON: Tactics & Equipment	DATE: 8/16/67
TIME PERIOD (TOTAL): 15 Minutes	PLACE: W.O. (Rosslyn)
TYPE OF LESSON: Lecture with Quiz	
CLASSROOM:	ASSISTANTS:

TRAINING AIDS: Slides, OH Charts, Flip Charts, Reference Books.

OBJECTIVES: Relative to Tactics & Equipment, trainees will be: (1) Made aware of suggested sources of information for followup self-training, (2) shown sample statements from several study reports and (3) given a list of questions as examples of the type they as analysts should think in terms of.

INSTRUCTOR REFERENCES: Instructions for Studying Large Fires; Sample Study Reports - Coyote & Nevada; NFCS Final Report.

HANDOUTS:
#1 - Trainee Reference List.
#2 - Tactics & Equipment - sample questions for analysts.

QUIZ: Add one or two additional questions to the samples on handout.

A. INTRODUCTION: Gentlemen, I am sure your own experiences have confirmed the necessity long ago for using the right tools for each job at hand (Slide #1). A situation as shown here usually demands only limited resources. (Slide #2). Something of this nature requires much more in the way of equipment. (Slide #3). And a disaster involving such an area as this presents still a different series of tactical requirements, just as this scene has unique aspects too (Slide #4), (Slide #5 - Discussion) .....

Now that we have covered that particular terrain hurriedly, let us try to focus the discussion toward our immediate objectives which are:

1. To give you a few references which you can use in your self-training efforts.

2. Show you some samples of statements about tactics and equipment from some study reports.

3. Stimulate your thinking as to the lines of questioning you as fire analysts should apply.

Please feel free to break in at any time with comments or questions.

B. PRESENTATION:

INSTRUCTION STEPS	KEY POINTS
1. Trainee references	1. Handout #1 (OH-A) a. Forest Fire Control - Davis Chap. 11, 12 & 13. b. FMS 5120, 5130, 5160 & 5700. c. Fire Fighters Guide - Florida Forest Service. d. Air Operations for Forest, Brush and Grass Fires - NFPA. e. A survey of Human Factors Engineering Problems in Fire Fighting Equipment - Serendipity Assoc. (NFCS). f. The Fireman Magazine.
2. Excerpts from study reports.	2. a. OH #1 (Nevada Fires - pg 11) b. OH #2 (Nevada Fires - pg 13) c. OH #3 (Nevada Fires - pg 17) d. OH #4 (Coyote Fire pp 57-58)

INSTRUCTION STEPS	KEY POINTS
	e. OH #5 (Coyote Fire pp 69 & 71).
	f. OH #6 (Coyote Fire pg 4)
3. Analysis Questions	3. Handout #2 (Item 12 - Instructions for Studying Fires).
4. Quiz - Add 1 or 2 appropriate questions.	4. Post others as offered on Flip Chart after each trainee has had a few moments to think independently.

INSTRUCTOR'S LESSON PLAN

SUBJECT: THE STUDY OF LARGE FIRES	INSTRUCTOR: Frank Lewis
TITLE OF LESSON: Weather Factors	DATE: 8/16/67
TIME PERIOD (TOTAL): 15 minutes	PLACE: W.O. (Rosslyn)
TYPE OF LESSON: Lecture with Quiz	
CLASSROOM:	ASSISTANTS:

TRAINING AIDS: OH Charts, Flip Charts, Reference Books

OBJECTIVES: As related to weather factors in connection with studies. (1) Trainees will be aware of sources of information on Fire Weather for use in followup self-training, (2) Trainees will have had exposure to samples of analyses and reports prepared on fires in the pase, and (3) Trainees will be shown examples of the type of questions that analysts should ask.

INSTRUCTOR REFERENCES: (1) Defending the U.S. from Nuclear Fire, NFCS Final Report; (2) Fire Study Reports - Coyote Fire, Nevada Fire, Eldorado Fire (PSWF & RES - Craig Chandler) (3) Instructions for Studying Fires.

HANDOUT: #1 - Trainee Reference List.
#2 - Weather Factors - sample questions.

QUIZ: Add two additional questions to the samples on handout

A. INTRODUCTION: (Flip Chart #1 - FIRE WEATHER FACTORS)

The next aspect of large analysis about to be discussed is Weather Factors.

This session is not intended to serve as a short course in fire behavior or fire weather. Neither is it intended to make you into a meterologist

or systems analyst. If you just happen to be an expert in one or more of these specialties, then you are in an excellent position to contribute to the discussion which is encouraged at any time. In any case, the immediate objectives will be to:

(Flip Chart #2 - OBJECTIVES)

1. Give you a few references which you can review on your own.
2. Show you some samples of Weather Factors as covered by analysts in several previous efforts.
3. Hopefully stimulate your thinking as to the type of questions you as an analyst ought to ask when conducting a study.

B. PRESENTATION:

INSTRUCTION STEPS	KEY POINTS
1. Selected references on Fire Weather and Fire Behavior.	a. OH Chart #1 (1) Forest Fire Control - Davis, Chapters 4 & 5. (2) Weather - Golden Pocket Book. (3) FSM 5120 and 5130 (4) Films - Introduction to Fire Behavior & Fire Weather. (5) Research Notes, Papers and Reports. b. Handout #1 - Reference List. c. Add to this list.

INSTRUCTION STEPS	KEY POINTS
2. Sample study report statements and summaries	2. a. OH Chart #2 (Coyote Fire - pg 9) b. OH Chart #3 (Coyote Fire - pg 18) c. OH Chart #4 (Coyote Fire - pg 65) d. OH Chart #5 (Coyote Fire - pg 71) e. OH Chart #6 (Coyote Fire - pg 72) f. OH Chart #7 (Coyote Fire - App. D. pg 1) g. OH Chart #8 (Coyote Fire App. H)
3. Analysis questions - the kind the analyst should ask himself and others.	3. Handout #2
4. Quiz - add 1 or 2 appropriate questions.	4. Flip Chart & Magic Marker - write them down after a minute or so (for each trainee to get his answer down).

INSTRUCTOR'S LESSON PLAN

SUBJECT: THE STUDY OF LARGE FIRES	INSTRUCTOR: Frank Lewis
TITLE OF LESSON: Evacuation	DATE: 8/16/67
TIME PERIOD (TOTAL): 10 Minutes	PLACE: W.O. (Rosslyn)
TYPE OF LESSON: Lecture with Quiz	
CLASSROOM:	ASSISTANTS:

TRAINING AIDS: OH Charts, Flip Charts

OBJECTIVES: Evacuation will be treated in the following manner for the specified purpose: (1) Trainees will receive a reference list for their use in followup self-training, (2) sample statements from a study report will be presented to suggest approaches trainees can use, and (3) a list of questions of the type analysts should apply will be given trainees to build upon.

INSTRUCTOR REFERENCES: Instructions for Studying Large Fires, Coyote Fire Study Report, Fire Bibliography (NFCS).

HANDOUTS: #1 - Trainee Reference List
#2 - Evacuation - sample analysis questions.

QUIZ: Trainees add 1-2 additional questions of own to the samples on Handout #2.

A. INTRODUCTION: An element common to fires in mixed urban-rural environments is often the necessity for evacuating people from the area. I am sure you appreciate the fact that the manner in which this task is accomplished and its timeliness, not only has a definite bearing on the survival of people, but the control of the fire. In large or mass fire situations, this phase can be extremely complicated.

(Flip Chart #1 Evacuation)

(EVACUATION - continued)

B. PRESENTATION:

INSTRUCTION STEPS	KEY POINTS
1. Examples of Evacuation covered in some references (case studies on this phase of large fires of the past seems rare - NFCS Bibliography).	1. Handout #1 (OH-A) a. Malibu Fire - Calif. 1956; NBFU, NFRA & PSWF&RES repts. b. Harlow Fire - Calif. 1961; NFPA & PSWF & RES repts. c. Bel Air Fire - Calif. 1961; NFPA, NBFU & LAFD repts. d. Santa Rosa Fire - Calif 1964; NFCS & CDF repts. e. Maine Fires - Maine, 1947; Several available (NFCS).
2. Comments from Coyote Fire Study Report.	2. a. OH #1 (Coyote Fire - Pg 15) b. OH #2 (Coyote Fire - pg 22) c. OH #3 (Coyote Fire - pg 26) d. OH #4 (Coyote Fire - pp 52-53) e. OH #5 (Coyote Fire pp 70, 71, 72).
3. Analysis type questions	3. Handout #2 - Item 9, Instructions for Studying Large Fires).
4. Quiz - Add 1 or 2 appropriate to handout.	4. Post on Flip Chart trainee suggested questions (after each has had a chance to think and record own thoughts).

INSTRUCTOR'S LESSON PLAN

SUBJECT: THE STUDY OF LARGE FIRES	INSTRUCTOR: Frank Lewis
TITLE OF LESSON: Cost-Benefit - Values sacrificed	DATE: 8/16/67
TIME PERIOD (TOTAL): 15 Minutes	PLACE: W.O. (Rosslyn)
TYPE OF LESSON: Lecture with Quiz	
CLASSROOM:	ASSISTANTS:

TRAINING AIDS: OH Charts, Flip Charts, Reference Books

OBJECTIVES: As it pertains to Cost-Effectives, Analysis Trainees will: (1) Be made aware of the intention to assess protective measures as they exist, or as they are taken, to serve as guides in planning for nuclear fire protection. (2) Receive a list of some suggested references for self-training, (3) Review some examples in previous fire study reports (4) Be able to list the type of questions that should be used by the analyst.

INSTRUCTOR REFERENCES:
(1) NFCS Final Report - page B-15
(2) NFCS Study - Nevada Fires
(3) NFCS Study - Coyote Fire
(4) Instructions for Studying Fires - NFCS

HANDOUTS:
1 - Trainee Reference List
2 - Cost-Benefit Analysis Questions

QUIZ: Trainees ad 1-2 additional questions of own to the samples on Handout # 2.

A. INTRODUCTION: (Flip Chart # 1 - COST BENEFIT, etc.)

We come to the portion of the effort to be made in studying large fires which all too often in some of our past endeavors on fires

(COST BENEFIT - CONTINUED)

and other activities has gotten rather light treatment. Economics never was one of my forts I'll admit, but PPBS and similar corrals have stimulated by thinking a little in the area.

The preceding discussions concerning - Protecting Key Structures, Control Objectives, Estimating Needs and Tactics and Equipment and several which are to follow are all important in themselves, but adequate treatment of "Cost-Benefit Factors in Strategic Decisions - Values sacrificed and Values Gained must be made by the analyst. Now again, this brief discussion is not going to suddenly turn all of us into economists, management analysts or similar creatures.

The objectives here in the next few minutes will be to:
(Flip Chart #2)

1. Acquaint you with the study objective which is the relate effectiveness of strategy, tactics and logistics commonly used in suppressing large fires to the problem of suppressing fires where nuclear fallout is involved.

2. Provide you with a list of references which you may use to do some follow-up self-training.

3. Review a few examples of Cost-Benefit analysis from fire study reports.

4. Get you thinking about the type of questioning that analysis of this aspect of fire suppression will require.

(COST BENEFIT - CONTINUED)

B. PRESENTATION:

INSTRUCTION STEPS	KEY POINTS
1. Assessing the effectiveness of protective measures	1. a. OH Chart # 1 - NFCS Final Report b. Proj. 83 - Fire Studies Objectives OH # 2 HANDOUT # 1 (OH#A)
2. References for self-training	2. a. Forest Fire Control - Davis, Chapter 17 (Least Cost plus Damage Adequate Control, Allowable Burn, Maximum Fire Size Fire Work Period, Control etc. b. Forest Economics & Finance - Buttrick, Chapter XVL, The Economics of Protecting Recreation and Wildlife Forestry, Chapter XVIII The appraisal of Forest Values. c. A Study to Analyze & Improve Procedures for Fire Damage Assessment Following Nuclear Attack - Jewell & Willough by (NFCS Final Report Bibliography) d. Protecting Your City From Conflagration - By Desing - NFPA Rept. MP-65-1. e. FSM 1310, 2100, 5120 and 5130 f. Economic Analysis - Boulding
3. Sample statements on Cost-Benefit from fire studies	3. a. OH # 3 (Nevada Fires - page 3) b. OH # 4 (Nevada Fires - page 4)

(COST BENEFIT - CONTINUED)

INSTRUCTION STEPS	KEY POINTS
	c. OH # 5 (Coyote Fire - Page 43)
	d. OH # 6 (Coyote Fire - Pages 48 - 50
	e. OH # 7 (Coyote Fire - Page 67)
	f. OH # 8 (Coyote Fire - Page 69
4. Some questions to apply when analyzing a fire as to cost-factors	4. a. Handout # 2
5. Quiz - add 1 or 2 to the above list of questions	5.a. Use Flip Chart & Magic Marker to take down questions after a minute or two for individual effort.

INSTRUCTOR'S LESSON PLAN

SUBJECT: THE STUDY OF LARGE FIRES	INSTRUCTOR Frank Lewis
TITLE OF LESSON: COMMUNICATIONS	DATE: 8/16/67
TIME PERIOD (TOTAL): 15 Minutes	PLACE: W.O. (Rosslyn)
TYPE OF LESSON: Lecture with Quiz	
CLASSROOM:	ASSISTANTS:

TRAINING AIDS: OH Charts, Flip Charts, Reference Books

OBJECTIVES: Approaches to analysis of communications in large fire situations will be covered so that trainees will (1) Have a start on a reference list for further self-training. (2) Be exposed to sample material from fire study reports.(3) Be introduced to some typical questions an analyst might use.

INSTRUCTORS REFERENCE: Instructors for Studying Large Fires,
NFCS Reports - Coyote and Nevada Fires
NFCS Final Report.

HANDOUTS: # 1 - Trainee Reference List
2 - Analysis Questions - Communications.

QUIZ: Add to Handout # 2 - 1 or 2/trainee.

A. INTRODUCTION: (Flip Chart - COMMUNICATIONS)

Here is an aspect of large fires that often comes in for much discussion in fire analyses. Seldom, however, do the comments seem to pin point the specifics of the problem, and less often are

remedial measures suggested except perhaps something such as "more and better communications are needed" Also, guidelines for communication systems analysis are not seemingly very well understood by many fire managers. Hence, it would seem adviseable to invite communications engineers versed in system design to help gather or review data compiled on fires.

Despite our perhaps limited personal knowledge we can do a few things to equip~~ment~~ ourselves to analyze communications on large fires.

B. PRESENTATION

INSTRUCTION STEPS	KEY POINTS
1. References for self-training	1. Handout # 1 (OH-A) a. Final Report NFCS b. FSM 7200 c. Federal Civil Defense Guide - Part E, Chapter 3 d. California Disaster Plan - CDO
2. Statements from fire study reports	2. a. OH # 1 (Nevada Fires - page 9) b. OH # 2 (Nevada Fires - page 16) c. OH # 3 (Coyote Fire - page 41) d. OH # 4 (Coyote Fire - page 69)
3. Analysis questions	3. Handout # 2
4. Quiz - add to handout lot of analysis questions	4. Post on Flip Chart - after individual efforts made.

INSTRUCTOR'S LESSON PLAN

SUBJECT: THE STUDY OF LARGE FIRES	INSTRUCTOR: Frank Lewis
TITLE OF LESSON: RESOURCE LOCATORS	DATE: 8/16/67
TIME PERIOD (TOTAL): 15 Minutes	PLACE: W.O. (Rosslyn)
TYPE OF LESSON: Lecture with Quiz	
CLASSROOM:	ASSISTANTS:

TRAINING AIDS: OH Charts, Flip Charts, Reference Books

OBJECTIVES: As to Resource Locators, trainees will be (1) acquainted with the state of the art by citing some references for self-study, (2) shown statements concerning systems from several fire reports, and (3) encouraged to build a list of analysis questions for use in studying future fire situations.

INSTRUCTORS REFERENCE: Instructions for Studying Large Fires, sample Study.Reports NFCS - Coyote and Nevada

HANDOUTS: # 1 - Trainee Reference List
2 - Suppression & Rescue Inventory, Dispatching and Locating System sample analysis questions.

QUIZ: Add to Handout # 2 - 1 or 2 per trainee.

A. INTRODUCTION: (Flip Chart - "Resources Inventory, Dispatching and Locator System"). The next phase of Large Fire Studies we are about to give a once-over-lightly treatment is ..... (point to chart)..... Among the many things which determine the efficiency with which a particular fire is fought is how well manpower and equipment available is mobilized, assigned, shifted, rescued, demobilized, etc.

Obviously the complexity can assume horendous proporation! (OH Charts A and B)

B. PRESENTATION

INSTRUCTION STEPS	KEY POINTS
1. Trainee References for self-training	Handout # 1 - (OH-C) 1. a. NFCS repts. on Resource Locator development Bio-Dynamics. b. FSM 5120 & 5130 c. 1966 Fire Generals School (Lesson plan for Dispatching and adjustments in for the large fire - Ed Heilman d. Dispatching Plans & Systems local & regional. e. Fire Control Command Center - unpublished slide talk by C. Phillips, CDF. f. "Dispatching Systems" USFS & CDF
2. Statements - from Nevada and Coyote Study Reports	2. a. OH # 1 (Nevada - page 7) b. OH # 2 (Nevada - page 10) c. OH # 3 (Nevada - pages 13 & 17) d. OH # 4 (Coyote - pages 22 & 23) e. OH # 5 (Coyote - pages 39, 40, 41) f. OH # 6 (Coyote - pages 69 & 71)
3. Analysis questions	3. Handout # 2 (Item Instructions for Studying Large Fires)
4. Quiz - Add to handout	4. Post trainee contributions on Flip Chart - after each has thought out his own.

NUCLEAR ATTACK AND INDUSTRIAL SURVIVAL

The Editors of McGraw-Hill consider this report the most critical assignment ever undertaken by our segment of the business press of this nation. In its development, at one moment or another, each member of the task force has felt the enormous contemplative weight of the subject and the almost overwhelming demands for accuracy. Rarely have we dealt with a matter of such potential import to individuals and to responsible leaders in all segments of the American economy. Never before have we volunteered as much effort, hoping it would not be needed.

However, not only now during the Berlin crisis, but probably for many years to come, the U. S. will live under threat of a nuclear attack. How well we could survive such aggression, and how rapidly we could restore a viable civilization, depends heavily on how we prepare to meet the danger.

And yet, paradoxically, we are aware that the very effort to do this work . . . or even to address this subject . . . is controversial. There are those, in highly respected echelons of our society, who say no civil defense is worthwhile . . . that the more security you feel, the more willing you are to risk the holocaust.

- Our study of nuclear attacks, and consultations with experts both within government and outside, convince us that responsible and prudent management can, and should, act on the basis that protective measures constitute a sound form of insurance.

- We believe the suggestion that a sense of security might provoke aggression libels both the intelligence and the morals of the American people. Nothing in this report, or in any other realistic appraisal of this somber subject, encourages aggression or bravado. On the contrary, the awe-full dimensions of destruction . . . despite all preparations for protection . . . compel the utmost effort for prevention of nuclear war.

This report concentrates on the problems of U.S. *industrial* survival for two important reasons. First, the excellent organization that industry already has can be a powerful force for the protection of people. Second, in the aftermath of any war, it is vital to society that production be restored as quickly as possible. Therefore, in planning for both survival and recovery, business and industry have special responsibilities . . . to employees, to the community, and to the nation.

Let us make one thing absolutely clear. If any part of the pages that follow can be accused of sensationalism, then we have failed our job. The Editors of McGraw-Hill do not believe that nuclear war is likely. But we do believe that the possibility of it . . . however remote . . . must be examined.

The Editors of McGraw-Hill

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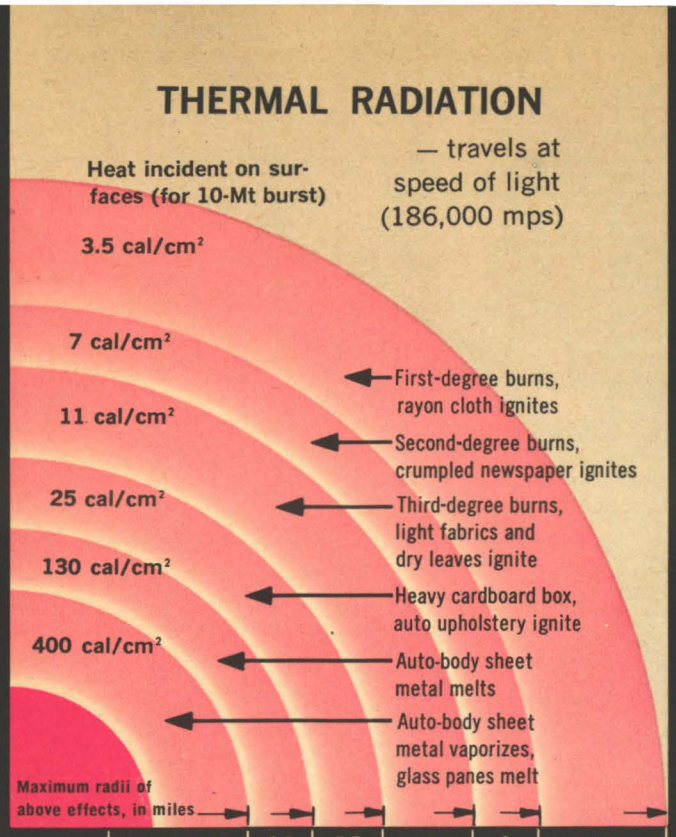
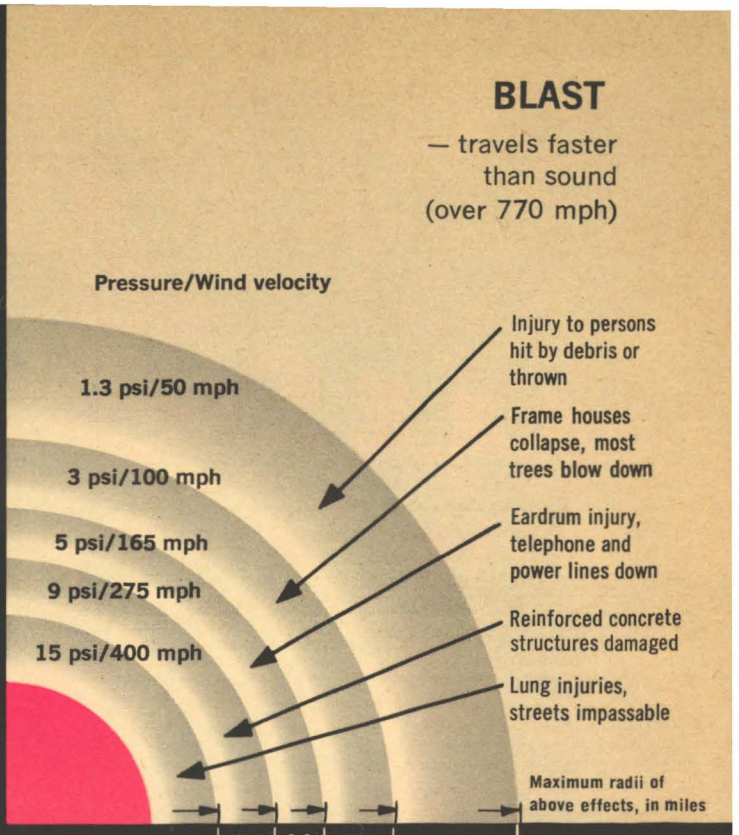

THERMAL RADIATION
— travels at speed of light (186,000 mps)
Heat incident on surfaces (for 10-Mt burst)
3.5 cal/cm²
7 cal/cm²
11 cal/cm²
25 cal/cm²
130 cal/cm²
400 cal/cm²
First-degree burns, rayon cloth ignites
Second-degree burns, crumpled newspaper ignites
Third-degree burns, light fabrics and dry leaves ignite
Heavy cardboard box, auto upholstery ignite
Auto-body sheet metal melts
Auto-body sheet metal vaporizes, glass panes melt
Maximum radii of above effects, in miles

1 Mt	Air	1.5	2.7	5.5	8	9	13
	Surface	0.9	1.6	3.3	5	5.5	8
10 Mt	Air	4	7	15	22	25	35
	Surface	2.4	4	9	13	15	21
100 Mt	Air	11	19	45	60	70	100
	Surface	6.5	11.5	27	36	42	60

2. About 35% of total bomb energy goes out in a burst of heat, uniformly radiated. Heat level falls rapidly with distance, as shown in calories per square centimeter at successive circles, above. Figures below give clear-day radii of circles for three weapon sizes, two types of burst. Also shown are possible effects on materials, people


BLAST
— travels faster than sound (over 770 mph)
Pressure/Wind velocity
1.3 psi/50 mph
3 psi/100 mph
5 psi/165 mph
9 psi/275 mph
15 psi/400 mph
Injury to persons hit by debris or thrown
Frame houses collapse, most trees blow down
Eardrum injury, telephone and power lines down
Reinforced concrete structures damaged
Lung injuries, streets impassable
Maximum radii of above effects, in miles

Air	1.4	2.6	3.9	5.3	8.8
Surface	1.5	2.0	2.9	4.0	7.2
Air	3	5.6	8.5	11.3	18.5
Surface	3.2	4.4	6.1	8.5	15.5
Air	6.5	12	18	24.5	40
Surface	6.9	9.5	13	18	33

3. About 50% of bomb's total energy goes into blast; the front of the blast, called the "shock front", travels rapidly away from the fireball, behaving like a moving wall of compressed air. Chart above shows various levels of blast pressure, equivalent wind velocities, and possible effects in the annular zones between successive circles

itself lethal over an area about the size of the fireball. This radiation includes high-energy neutrons and gamma rays. Additional gamma rays come from radioactive bomb materials and fission products.

Heat and fire. The fireball sends out *thermal radiation* in two pulses, making up 35% of the bomb's total energy. The first pulse, a split-second ultraviolet flash, isn't a major hazard. But the second is: mostly infrared, it carries nearly all the heat of the burst, lasts several seconds. As the heat radiates from the fireball, it spreads over ever greater areas, so heat levels diminish sharply with distance (Fig. 2). Low clouds or fog tend to cut heat, but high clouds can act as reflectors, raising heat levels on the ground.

Because heat is applied only for a matter of seconds, light, easily kindled materials are most likely to ignite. But surveys show typical American cities contain 5 to 25 points per acre where fires might begin from thermal radiation. Although it's hard to predict precisely, there's a danger that many small fires might merge into single, great "firestorms", with strong updrafts at center creating violent cyclonic winds.

Thermal radiation travels like light. So ducking quickly into a shadow or covering exposed skin with clothing offers some personal protection.

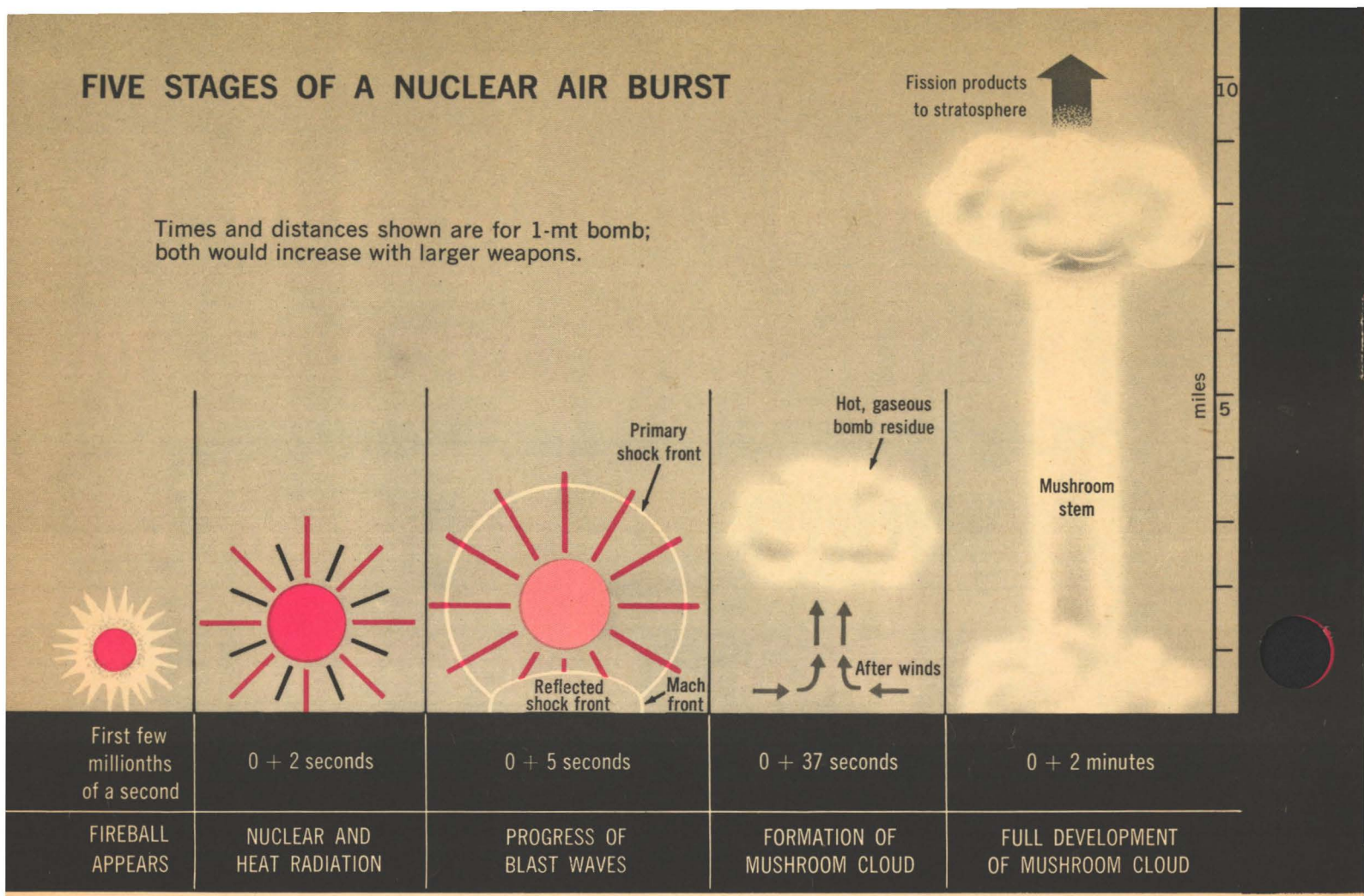
Shock pressures. In about the time it takes for a thunderclap to follow a lightning bolt, the blast wave follows the thermal flash; about 50% of weapon energy is in this form. The blast wave starts as a high-pressure shock front, traveling somewhat faster than the speed of sound. After a few seconds, a negative-pressure phase follows. The effect is to first squeeze and then expand or explode structures and human tissues.

Along with these great swings in pressure, there would be short wind gusts of enormous velocities — up to 1000 mph near ground zero. Drag forces of these winds would inflict much of the damage to buildings and the bulk of blast injuries to humans. As Fig. 3 shows, shock pressures in themselves would be fatal over only a small area by comparison with the area in which pressures and winds would hurl people and objects through the air to cause injury and death.

Near ground zero, pressures and winds are higher in a surface burst than an air burst. Farther out, an air burst creates stronger pressures and winds because the blast wave bounces off the earth and reinforces the primary wave to create the so-called "Mach front" (Fig. 1).

In areas of heavy blast damage, fires will be started by broken gas mains and electrical short circuits. They will feed on the kindling produced by the blast.

Thanks to the relatively slow speed of the blast wave, there is often time to take evasive action, such as dropping flat, or seeking shelter below ground.



1. Instant release of bomb's vast energy raises temperature of its materials several millions of degrees, gasifies them to form a roughly spherical luminous mass. Emitting nuclear and thermal radiations, this "fireball" grows and rises. For a 1-mt weapon, maximum diameter of 1.4 mi is reached in about 2 seconds. Very shortly after explosion, shock wave develops and moves rapidly away from fireball. When shock wave reflected from earth surface meets primary wave, the reinforced "Mach front" forms and moves outward. Rising ball of fire, no longer luminous, creates strong updraft and "after winds" that raise dust and debris. With condensed bomb residue, these form radioactive cloud

NUCLEAR EXPLOSIONS: What are the immediate effects?

The split-second blast of a modern nuclear weapon lets loose awesome amounts of energy — so awesome, in fact, that it is usually measured by comparison with the force of thousands or millions of tons of TNT (*kilotons* or *megatons*). It would take a block of TNT the size of New York's Empire State Building to duplicate the energy release, or *yield*, of a 2-megaton nuclear bomb.

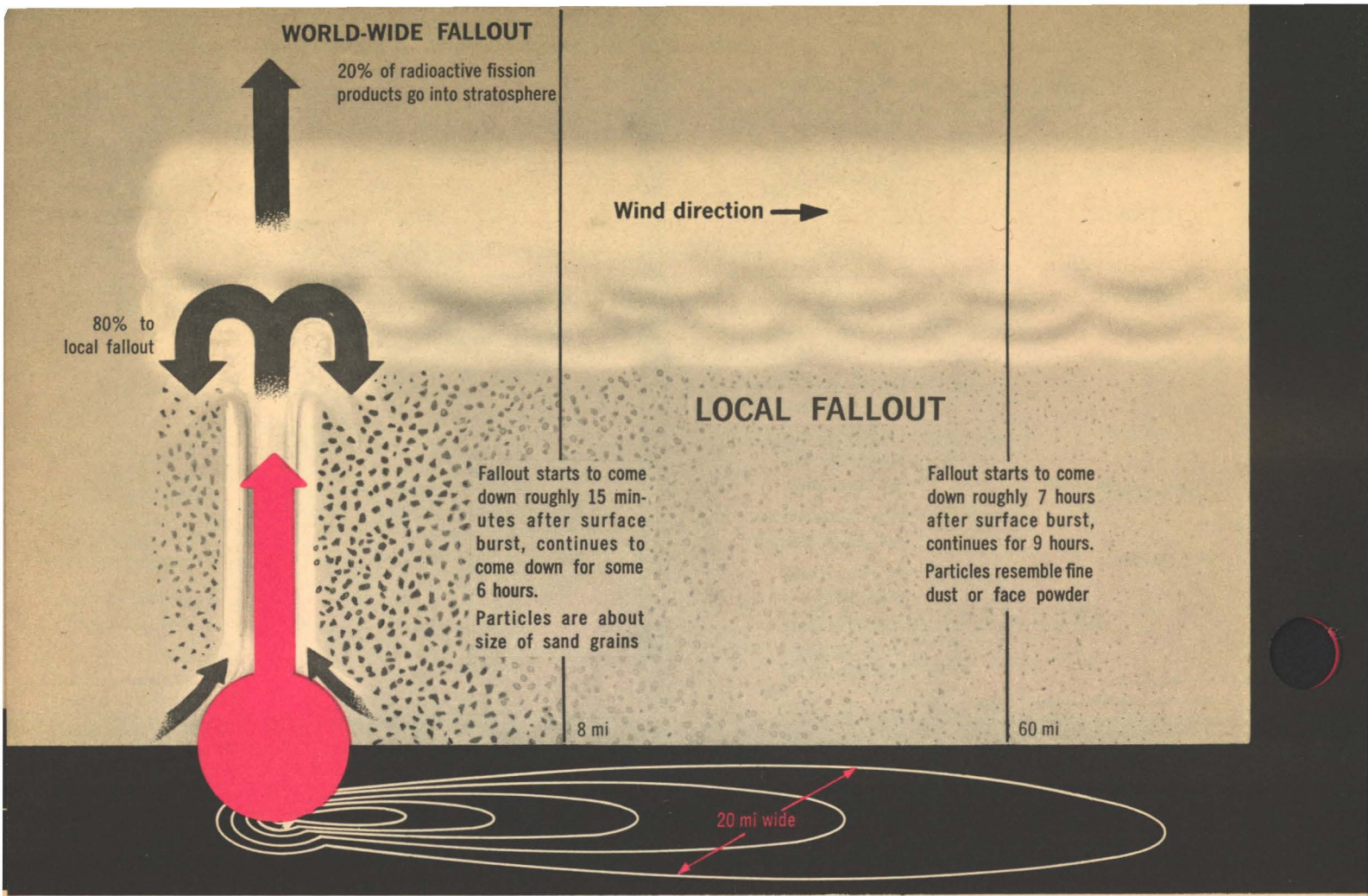
How can you pack that much wallop into the warhead of an ICBM? The answer lies in the way a nuclear explosion unlocks the vast forces inside the nucleus of the atom. There are two techniques for doing this:

- In *fission*, you split the nucleus of a heavy element — such as uranium-235 or plutonium — into two lighter nuclei, called *fission products*. If fission were 100% complete — it isn't — 1 lb of U-235 would produce the energy of 9000 tons of TNT.
- In *fusion*, you cause two light nuclei to unite into a single heavier one. Fusion will create, from the same mass of material, nearly three times as much energy as does fission. But to trigger the fusion process, you need temperatures akin to the heat of the sun. To produce this heat, you use a fission explosion. Fission triggers fusion. Then, as an extra dividend, more fission results because fusion liberates high-energy neutrons that split some of the atoms left intact by the first fission. This combination — fission, fusion, then more fission — adds up to the terrible energies of today's thermonuclear weapons.

Sequence of events in a nuclear explosion appears in Fig. 1, above. First there's a flash of light that can be literally blinding — eyes turned directly toward it suffer retinal burns, even at distances of hundreds of miles with megaton blasts. How much damage is done to the eye depends on such factors as weapon size, height of burst, time of day, weather, and speed of blink reflex.

Millionths of a second after the bomb is detonated, the *fireball* forms and grows by engulfing surrounding air. In about two seconds it reaches a maximum diameter of 1.4 mi for a 1-megaton (1-mt) bomb. Maximum diameter is 3.4 mi for 10 mt, 4.6 mi for 20 mt. When the burst is low, and the fireball touches earth, all above-ground installations within it are vaporized or otherwise destroyed, except for heavy concrete structures.

Simultaneously, the explosion releases an initial burst of radiation — about 5% of the bomb's total energy — that is


WORLD-WIDE FALLOUT
20% of radioactive fission products go into stratosphere
Wind direction
80% to local fallout
LOCAL FALLOUT
Fallout starts to come down roughly 15 minutes after surface burst, continues to come down for some 6 hours.
Particles are about size of sand grains
Fallout starts to come down roughly 7 hours after surface burst, continues for 9 hours.
Particles resemble fine dust or face powder
8 mi
60 mi
20 mi wide

4. In contrast to air bursts (Fig. 1, page 4), where fallout goes mainly to the stratosphere and may travel far, surface bursts are characterized by heavy local fallout. This results from great amount of debris swept up into the fireball. Like the materials of the bomb, such debris is initially vaporized. Material swept up later may be only melted. When the vaporized materials, including fission products and materials made radioactive by neutron bombardment, condense into fine particles, many of these adhere to larger debris particles. Resulting size keeps particles from rising high, causes them to settle out over large areas as the radioactive cloud moves with the wind

NUCLEAR EXPLOSIONS: How fallout hazards develop

A nuclear explosion vents about 90% of its total energy immediately — in initial radiation, heat, and blast. The other 10% shows up afterward, mainly as radiation from fission products that rise with the mushroom cloud. Sooner or later, they descend to earth as *fallout*.

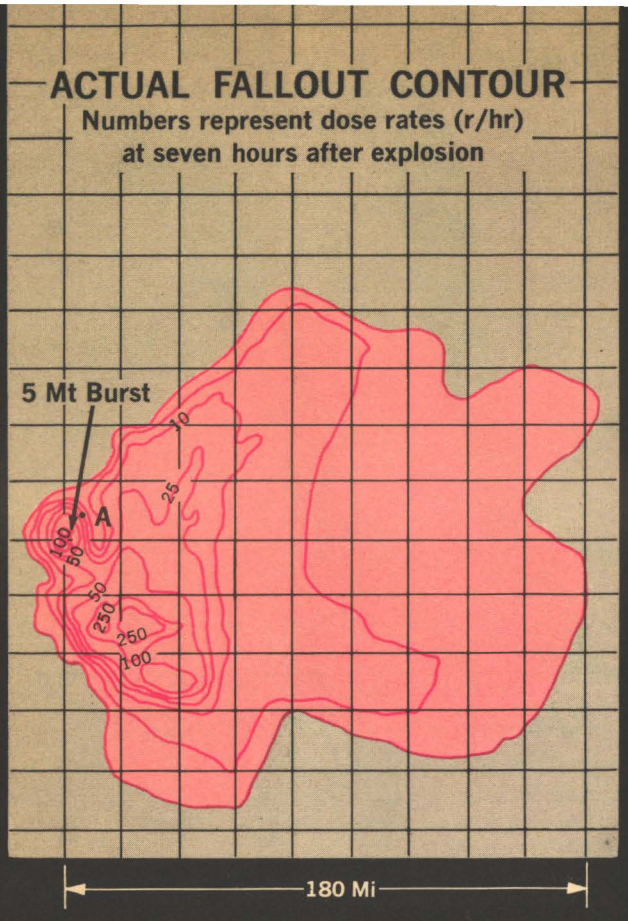
Fallout has its origin in the fission chain reaction that triggers the nuclear blast. This forms more than 200 different radioactive isotopes, which begin at once to *decay*, each at its own rate. Some decay almost completely in a matter of minutes, others so slowly that years later they are only slightly less radioactive. The differences in decay rate are a crucial factor in determining the hazards of fallout, and also in distinguishing between the two types of fallout — global and local.

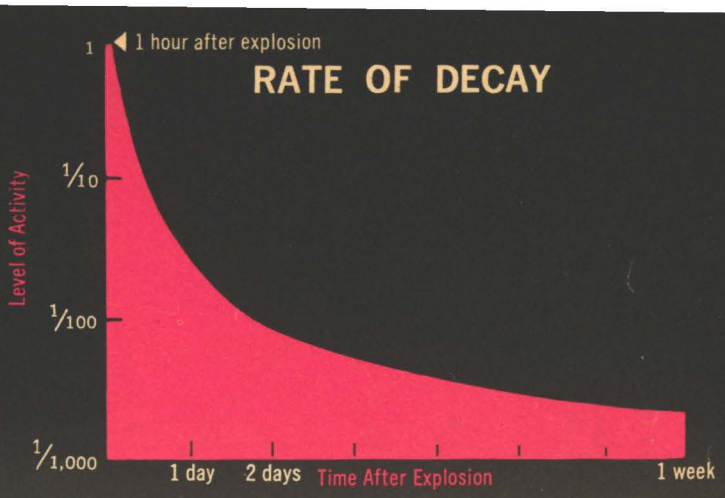
Global fallout is the type that has resulted from weapons tests already conducted, most of them air bursts (Fig. 1, p. 4). Fission products formed by such a burst first vaporize, then condense as extremely fine particles that rise into the stratosphere and travel with upper-level winds for long periods of time. Meanwhile, decay eliminates all but the long-lived isotopes, such as the much-discussed strontium-90. When the particles do drift down to earth, they are widely distributed. So they raise the radiation level at any given point only minutely.

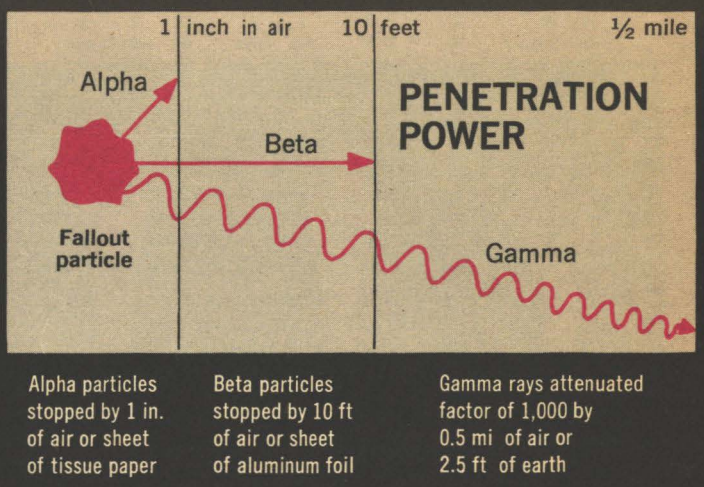
Such increases in radiation levels are considered to produce genetic effects. And strontium-90, moving from the earth's surface to plants and to food, can be selectively absorbed by the human body to cause bone cancer. Because these are all long-range effects, the impact of global fallout from nuclear tests is widely debated and will be truly known only in the future, when sufficient statistical data have been accumulated and analyzed.

Local fallout is much quicker to take effect — and much more dangerous. This type of fallout results from surface bursts, which would probably be part of a nuclear attack. Fission products from the explosion agglomerate with larger particles of debris (Fig. 4, above) and roughly 80% of them settle to earth in a matter of hours. Heavier particles descend in the first hour or so; lighter ones take several hours or more and winds carry them over hundreds of square miles. The major and immediate danger of this local fallout is radiation from these particles as they sift down over land and buildings.

The other 20% of the fission products from a surface






1 inch in air
10 feet
½ mile
Alpha
Beta
Gamma
Fallout particle
PENETRATION POWER
Alpha particles stopped by 1 in. of air or sheet of tissue paper
Beta particles stopped by 10 ft of air or sheet of aluminum foil
Gamma rays attenuated factor of 1,000 by 0.5 mi of air or 2.5 ft of earth

5. Theoretical pattern of fallout distribution at ground level appears at base of diagram on facing page. In contrast to this cigar-shaped pattern, actual distribution may be highly irregular, as illustrated above. Note particularly the several local "hot spots" and the fact that radiation intensities do not always fall off downwind

6. Radiation from fallout particles decays rapidly at the beginning, as shown in upper curve. This radiation takes three forms: Alpha and beta radiations consist of atomic particles that do not travel far, can be stopped easily. Gamma radiations are true rays, like X-rays. They can travel relatively far and they have great penetrating power

burst go into the stratosphere and become global, or worldwide, fallout. Because fission products are created in direct proportion to the amount of material exploded, a nuclear attack involving thousands of megatons would produce much more global fallout than has resulted from all the weapons tests so far.

Theoretical calculations to determine the distribution of local fallout usually assume that the wind blows in just one direction at 15 mph. Under such conditions, radioactive fallout will tend to settle in a cigar-shaped pattern (Fig. 4, bottom), with radiation intensity diminishing in the downwind direction and toward the outside edges.

In practice, however, winds at different altitudes move in different directions at different speeds. So actual patterns of fallout tend to be highly irregular (Fig. 5). This means that it isn't safe to use reports of general radiation levels as an estimate of hazards in your area. The only sure answer is to measure radiation locally.

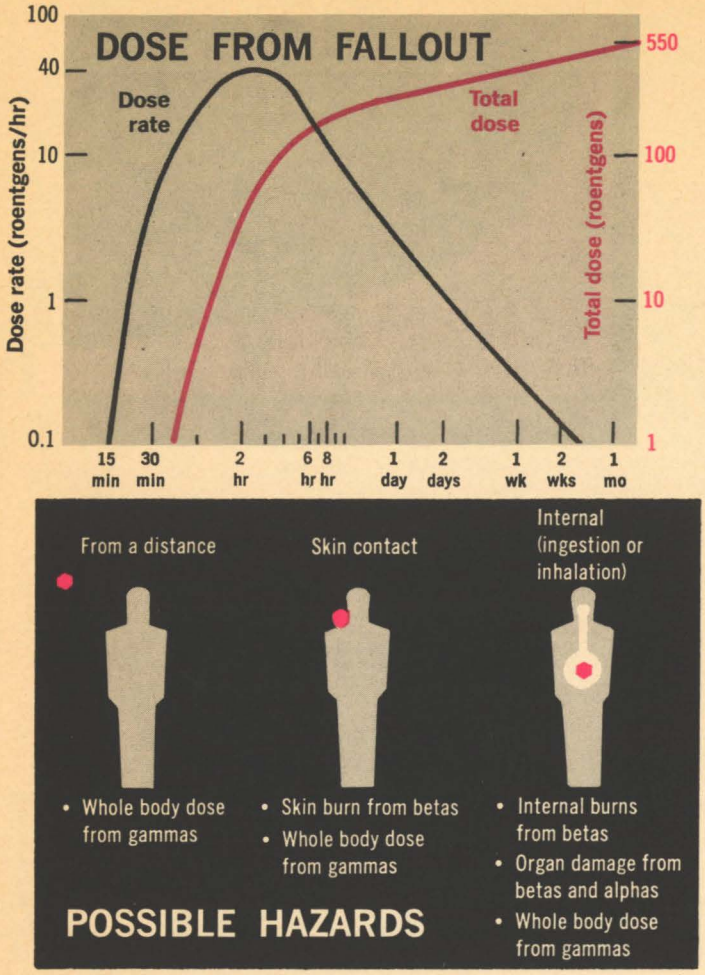
How to measure. Fallout particles emit three kinds of radiation (Fig. 6), but only one — *gamma* radiation — is of major importance. Gamma radiation is like X-rays and you gage exposure, or the *dose*, in the same units — *roentgens*. To measure the dose *rate* or radiation intensity, you use roentgens per hour (r/hr).

An instrument called a *dosimeter* will show the radiation dose to which you have been exposed. One common type, designed to be worn, is shaped like a fountain pen. Dosimeters of this sort usually record accumulated radiation up to about 600 r. In addition to keeping track of the total dose you have accumulated, you should also know the rate at which radiation is being received (r/hr). This can be crudely done with a dosimeter, by noting the increase in total dose over a period of time. For greater convenience and accuracy, a similar pen-shaped device is calibrated to read the rate up to 100 r/hr.

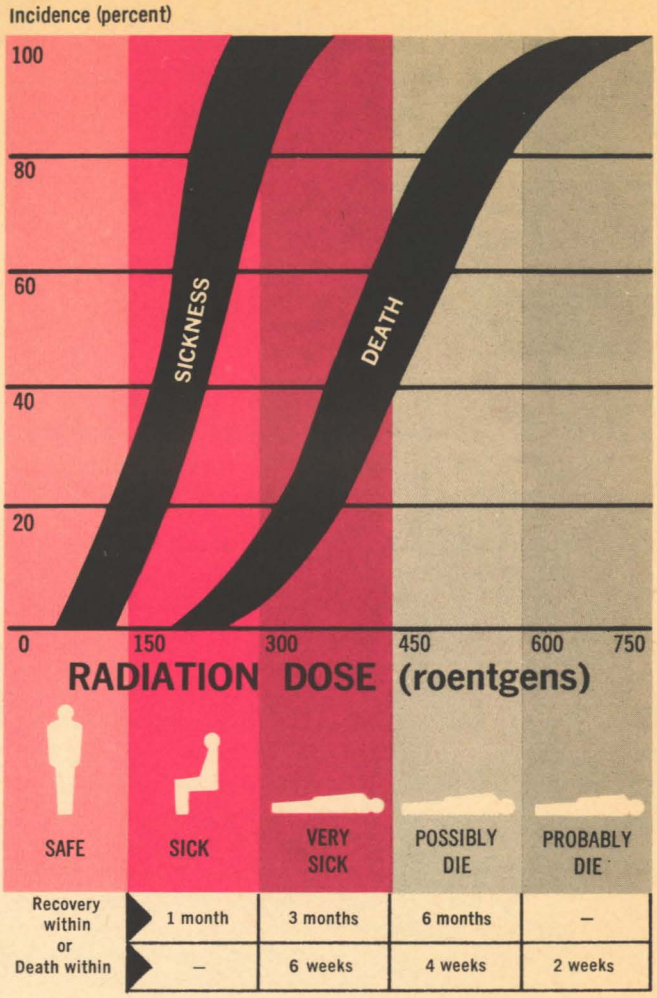
More elaborate portable *ratemeters* are on the market to indicate radiation intensities up to 500 r/hr — although at such high levels hand monitoring is dangerous. For more safety, you can install a stationary ratemeter — capable of registering levels of 1000 r/hr or more — and hook it up for reading in a protected location, such as a group shelter. To use the more elaborate instruments properly, operators would need a few hours of special training.

Speeds of decay. In appearance, fallout particles have a glassy surface. They range in color from white to black, and in size from clearly visible "sand" to barely visible powder (several thousand *microns* down to about 20).

In any group of fallout particles, there will be a wide variety of isotopes, each with a different decay rate. For mixed fission products, the radiation level starts high but drops quickly (Fig. 7), as the isotopes with rapid decay rates spend themselves. An easy rule of thumb is that for



7. Radioactive fallout particles (lower diagram) can injure from a distance, on skin contact, or internally. Upper diagram shows whole-body gamma dose received by an unsheltered person at point A, Fig. 5. Dose rate reaches a peak when fallout is complete, then decreases as radioactivity decays. In contrast, cumulative dose continues to rise



8. Effects of whole-body radiation doses can only be expressed statistically. Curves show percentage incidence of sickness and death in a group of exposed persons, for doses accumulated in a few days. Effects prove less severe if accumulated over weeks or months. As indicated at bottom, radiation sickness is usually a drawn-out process

each increase in time by a factor of seven, the radiation level decreases by a factor of ten: Seven hours after a burst, radiation level will be 10% of the level in the first hour.

In practice, however, it's not quite so simple. The first fallout might not arrive for 15 minutes or more after the explosion. But then fallout might keep coming for a time, and more than offset the decay that was occurring. As fallout slacked off, however, decay would begin to push radiation levels down, and after all fallout had arrived, the "rule of seven" would apply with reasonable accuracy for several months. So the rate of change in radiation would look like the humped curve in Fig. 7. But the dose accumulated by an exposed person would continue to increase, although more slowly after fallout has stopped coming down and the peak of the rate curve has been passed.

Radiation hazards stem from the fallout particles themselves. The air through which fallout passes, and the surfaces on which it settles, do not themselves become radioactive. Remove the particles and there is no danger.

Alpha and beta radiations from fallout particles penetrate such a short range that they are dangerous only if you cannot avoid inhaling, ingesting, or coming into skin contact with them. Gamma radiation is more perilous, however. It can be effective a considerable distance from the particle and has great penetrating power, hence ranks as a major hazard. An hour after a burst, the accumulated fallout on a 30x40-ft lawn — measuring at most 1/10 inch deep — might subject a person standing in the center to a dose rate as high as 1000 r/hr.

Effects of radiation on humans depend on such factors as age and general health. But statistical projections (Fig. 8) show that some people would not survive a dose of 300 r received over, say, 24 hours, while a few others would recover from twice this dose. Recent studies suggest that it is possible to survive even greater total doses accumulated in small units over long periods of time.

Radiation causes sickness primarily by damaging the blood-manufacturing centers in the bone marrow and lymph glands. In early stages it is usually accompanied by nausea, diarrhea, general malaise. These symptoms usually appear during the first day. Loss of hair, and skin ulcers, may follow in more severe cases. There is no specific treatment, but antibiotics and blood transfusions may help. Recovery is slow, involving weeks or months (Fig. 8). The sickness is not communicable.

For more details, consult "Effects of Nuclear Weapons" ($2) and "Comparative Nuclear Effects of Biomedical Interest" (CEX58.8) ($1), both published by the Atomic Energy Commission and for sale by Superintendent of Documents, Washington 25, D. C.

There is also a wealth of information in the record of hearings conducted by the Joint Committee on Atomic Energy (June 1959) and the Committee on Government Operations (August 1961).

SURVIVAL AND RECOVERY:

Why industry needs to plan now; how to go about it

What can business and industry do to prepare for the possibility of nuclear attack?

If your office or plant suffers a direct hit, obviously the answer is nothing. But the likelihood is that, even in a massive assault, the degrees of destruction would vary (pages 2 and 3). So you would have some chance to survive and to recover.

What plans should you make? As an executive, you are responsible for seeing that your company continues to exist and to function. In the narrowest sense, this responsibility is directly to the stockholders—the owners. More broadly, you have a responsibility to your employees, their families, the community, and the nation. Your company's organization and resources could be vital in coping with the crisis an attack would bring; the services it performs could be equally essential.

In the ordinary course of business, you plan some form of insurance to protect your company against a variety of risks — fire, windstorm, and so on. A large-scale nuclear attack is a risk that has never become reality. But it differs only in magnitude from the risks you routinely take into account. It is oversimplifying only slightly to say that you can apply the principles you use in preparing for other risks.

Seeking a balance. In building a conventional insurance program, you would try to assess the risk as realistically as possible — the degrees of damage that might be inflicted, how likely you are to suffer each degree of damage, how much it would cost to buy different amounts of protection. From these calculations, you would then strike some sort of balance, to give you the most protection possible for the money you can spend.

How would this approach apply, for example, to protecting your company's personnel from the effects of a nuclear attack?

You can't do much to protect against a direct hit, of course. But with nuclear attack, as with other risks, you don't assume that total loss is certain. The best estimates suggest that the most widespread danger will be from fallout. Second in order of probability comes fire; last is the combination of fire and heavy blast damage.

You must consider costs as well as probabilities. In general, the closer you might be to the target, the more it would cost to provide physical protection.

Balancing these two factors, it seems relatively easy to justify steps for protection against fallout. For a minimum investment, you can achieve some measure of protection against the most likely hazard.

But don't stop there: For comparatively little more money, you may be able to buy some degree of protection against fire and blast. It depends on your situation, of course; to find the most practical answer, you must weigh the increasing costs of greater protection against the decreasing scale of damage probabilities.

Plans such as this for protecting personnel are only part of the over-all thinking that should go into the effort to survive a nuclear attack—and recover. Ideally, you should consider every element of your company's operations—such matters as preserving its framework of organization, its assets of all kinds and the records that prove ownership, its productive knowhow. And, when new facilities are planned, you should consider the problems of survival under nuclear attack in their location and design.

Guidelines. To draw up an effective plan, you might think broadly along these lines:

- The plan should start with top management—and top management should give it continuing support. This means launching the preparations with a meeting of directors or key officers, assigning the planning job to responsible people, informing employees of the policy over the chief executive's signature.
- The plan should be firm. In other words, it should not ebb and flow with the tides of international tensions, as some past planning has done.
- At the same time, the plan should be frequently reviewed to keep it in tune with changing conditions. New weapons, for example, might make your previous preparations obsolete.
- The plan should suit the community. You should coordinate it with plans of local government and neighboring industries. You should also consider what to do about employees' families and nearby residents. But, in most cases, you probably shouldn't count on civil defense authorities to solve all your problems for you.
- The plan should be suited to your company — its own resources, problems, type of operations. Some companies have found that streamlined procedures devised for the emergency plan can be applied to make everyday operations more efficient.

These, in broad outline, are some of the goals to aim for in preparing a plan for your company. More details on how to plan follow.

SURVIVAL COORDINATOR

In a typical company's organization for survival, this would be the key man, directing, with top-management support, a Plant Survival Advisory Committee composed of the heads of the functions outlined (right). He would probably be chosen from upper management, since he must be well able to plan, organize, and delegate authority. He must believe in the importance of the job.

His first task would be to master the fundamentals of the assignment, by reading and special training. Then he would select top aides—who may now be heading up departments related to survival functions.

Broadly, the coordinator must plan the complete program for survival, help organize each of the functions, spell out responsibilities, designate shelter areas in existing buildings or provide for them in new ones, set up an emergency headquarters.

Other jobs would include linking the company's program with other community plans, arranging mutual aid, spotting vulnerable points in the utilities and process areas, preparing a survival manual for employees.

Periodically, the coordinator must report to top management on the company's readiness to survive an attack and on progress and shortcomings of the program to date.

The coordinator must always be alert to keep training and drills from slipping into routine. He should groom an assistant to step into his shoes. Finally, his compensation should reflect his importance.

ENGINEERING

Members of the company's engineering staff would form the nucleus of the survival engineering group. Its job: to design shelter areas, perhaps with consultants; to equip shelters with utilities — emergency generator, water, light, heat or cooling, ventilation and air filtration, sanitation; and to operate and maintain equipment in shelters.

Sanitation in shelters would be a major problem that engineers must carefully think through in all aspects—toilet facilities, garbage, housecleaning, burial of the dead.

Engineers would help the communications group decide what equipment is needed, then help install and maintain it.

They would also work with the radiological team on such matters as monitoring equipment, building and plant design features to make decontamination easier, radiological control of decontamination and plant repair procedures.

When an alert sounds, engineers must be ready to shut down the plant—and to reduce the risk that the halt in production might cause fire, explosion, or escape of dangerous fumes. Fuel lines should be closed, most circuit breakers tripped in main substation. However, it would be wise to use regular sources for electricity and fuel in shelters as long as they were available, to lessen the load-time on emergency sources.

Engineers must be prepared to make some repairs to shelters—from blast or fire damage, say—and to the plant after attack.

SHELTER MANAGEMENT

The team charged with shelter management would cope with all the problems of sustaining life in close quarters cut off from outside. Key men would probably come from the personnel department, with help from specialists in other areas. They would face problems such as:

- Mass feeding. The team would decide whether to use austerity rations, canned or dried, or a more nearly normal diet prepared in a shelter kitchen. It would also decide how much food to stock.
- Water. Questions would include how much would be needed, how to dispense.
- Sleeping accommodations. The program should set up a scheme for rotation; some people sleeping, others eating, etc.
- Assigning chores. This would keep people busy, shelter operating smoothly.
- Installing lockers. In these, employees could store personal needs in advance.
- Stocking supplies. The list would include reading and recreational materials, clothing, blankets, and so on.

To help bolster morale, personnel staffers should be able to draw on employees with special talents—excellent military records, entertainment ability, religious leadership.

The shelter management team would carry out the plan—if any—for accommodating employees' families in the shelter. It would work with the transportation team to evacuate shelters if necesary. And it would handle the many human problems.

THE SURVIVAL PLAN: How to set up the organization

Once your company decides to plan a survival program, the first step would be to appoint a coordinator, or director. Then management must work with him to form the organization he would head.

The key areas in such an organization are outlined above. To fit your own operation, it may be possible to eliminate or combine some of the areas; on the other hand, you might have others to add.

At the outset of planning, it would be wise to consider enrolling key personnel in the Office of Civil Defense Staff College at Battle Creek, Mich., for training in the problems they will face.

In developing your program, you can profit from a mutual-aid plan. Besides arranging to assist neighboring companies and the community in an actual emergency, you can exchange study results and balance one company's assets against another's liabilities — one may have abundant shelter space, another portable self-powered generating equipment, a third skilled disaster teams, a fourth large food supplies.

One of the first problems in your plant would be the attack warning system. Your internal system should be hooked up to receive the national alert instantly. Several techniques are under study for a nationwide alert; closest to reality is NEAR — for National Emergency Alarm Repeater — which uses existing electric power lines. Using a high-frequency signal, NEAR would reach about 95% of U.S. buildings within one minute. After hearing signal, you would turn on a radio for more information. NEAR units — expected to be available at low prices — could be plugged into any 120-v outlet.

The alarm in your plant should trigger production shutdown, and the moving of people to shelters.

Another immediate concern would be surveying how vulnerable the plant is to damage from attack. You should look, for example, for combustible materials that might easily be ignited, for large glassed areas that could be hit by blast, for narrow entrances or passages that could hinder the movement to shelters. You should also take note of points in the production process where damage or loss might cause major, long-time shutdowns.

Participation. Over-all, the urgent need in your planning would be to train personnel as quickly as possible, prepare them to be self-sufficient for some time after attack.

HEALTH

Looking after health problems would be the job of the plant physician, aided by his nursing staff and a special team trained in first aid and emergency medical care. Don't expect outside help until well after the attack.

Each shelter should contain at least one health station, stocked with drugs, oxygen, and supplies for treating the effects of possible chemical and biological warfare. There should be plans for meeting psychological problems.

With the shelter management team, the health director would plan for moving casualties to treatment stations and identifying them. This could be simplified by use of "dog tags."

FIRE AND RESCUE

A trained firefighter should guide this team. During attack, it would have two jobs—to control fire and to clear damage for health teams.

In the planning phase, this team would pinpoint plant areas where fire danger is greatest, such as stockpiles of flammable materials. If hazard can't be eliminated, engineering group may install sprinklers or other measures.

For effective rescue work, the team should have detailed knowledge of the plant's structure and production processes. This group would probably be last to enter shelters—and should be prepared to leave them for short, controlled periods to cope with emergencies.

RADIOLOGICAL

This vital team—most likely selected from the company's engineering staff—would focus on radiation problems. Among other things, it would:

- Estimate the protection from fallout that is available in various shelter areas.
- Buy radiation measuring instruments.
- Monitor radiation levels and be on alert for agents of chemical and biological warfare.
- Plot fallout patterns in surrounding areas.
- Record individual dosages of radiation.
- Analyze food and water to assess contamination—and supervise its removal.
- Working with the engineers, this group should plan, and supervise, decontamination.

COMMUNICATIONS

The goals of this group would be to link the company with the nationwide alert program, set up a plant warning system; provide for emergency telephone, telegraph, radio equipment; staff a communications center connecting all plant shelters; keep in touch with local civil-defense authorities and the community if possible, help employees contact families.

The team might also publish some version of the company newspaper in shelters, perhaps in mimeographed form. The shelter communications center should include a public-address system; it might sometimes be advisable to hook Conelrad broadcasts into this system.

SECURITY

Built around the company's present security force, this group would be an in-plant police team. The chief could recruit as aides employees with military or similar qualifications.

The men would need training in maintaining order, handling crowds, and coping with panic, and they should be prepared to prevent looting. They would map emergency routes to shelters, both inside and outside plant grounds.

At all times, this group should be on the alert for possible espionage and sabotage. It would establish liaison with state and local police and assist them in carrying out any emergency plans for community security.

TRANSPORTATION

Trucks and manpower would be needed before and after an attack. The core of this program would be a fleet of trucks well equipped for radiological monitoring, first aid, carrying casualties and supplies, emergency repair of utilities. These vehicles would link the company with others participating in a mutual-aid plan.

In developing emergency transportation plans, this group should tie in closely with local civil-defense authorities and should coordinate its efforts with those of other plants in area.

During the early period of recovery, bulldozers — possibly shielded — would push contaminated earth and debris away from the plant.

To be most effective, the company's plan should call for training all employees to take part in some way. Acceptance by employees could be encouraged by consistent management support, by constant efforts to keep the program vital and interesting, by regular checks of the coordinator's staff, by quick dissemination of the latest information on civil defense and community programs, by enlisting support from unions and community groups.

The problem of keeping a disaster team efficient — perhaps for years—challenges the resources of the most imaginative company officer.

To complicate the problem, the planning should include decisions on what to do about protecting off-duty employees, families, and such people as visitors and contractors who happen to be at the plant when attack strikes. If your community is one where families live fairly close to the plant, you might think seriously about accommodating them in the plant shelter, as part of your broad responsibility to employees and the community.

Sustaining morale. In setting up a shelter, you must consider more than engineering (pages 12-13) : One concern — largely unpredictable — is morale and discipline. Sweden has tried to ease the problem by using color and design extensively to make shelters brighter. Morale can also be influenced by such factors as the amount of space available to the individual; providing routines and chores, entertainment, spiritual guidance; keeping families together; and taking action in cases of hysteria and panic.

It would probably be best to leave discipline to supervisors and others accustomed to exercise authority. With training, the plant security force could help the shelter-management group to direct routines, and the medical team to handle shock and panic victims.

You should make generous provision for food, clothing, and blankets in the shelter. For the food planner, a great deal of information is already available. Perhaps the basic study is "Food Stockpiling for Emergency Shelters," published by the Food & Materials Div. of the U.S. Dept. of Agriculture's Commodity Stabilization Service. OCD and USDA offer many other pamphlets on the subject.

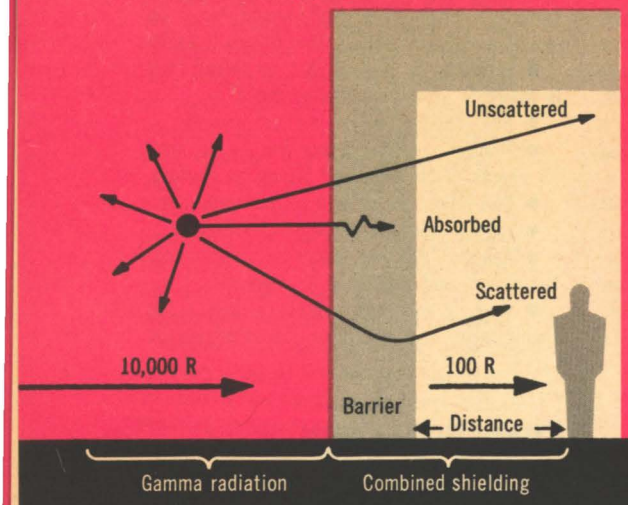
Another question would be how to distribute food in the shelter. If the company cafeteria can be moved into the shelter area, mass feeding is probably the answer — although cooking in the shelter would require some source of heat. Or you might decide on stocking individual rations that supply minimum requirements in concentrated form. A variety of such subsistence foods is already available and on the market.

Study of your plant and employees would probably reveal other special needs.

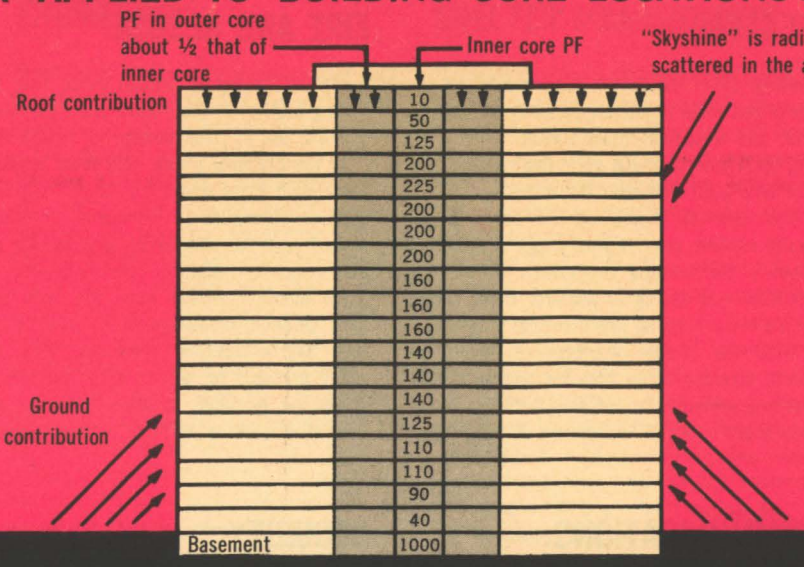
Engineering points to consider in planning a shelter are discussed on the following two pages.

FALLOUT PROTECTION FACTOR APPLIED TO BUILDING CORE LOCATIONS . . .

$$PF = \frac{\text{Radiation level outdoors}}{\text{Radiation reaching people}} \qquad PF = \frac{10{,}000\ R}{100\ R} = 100$$



PENETRATING POWER of gamma radiation through a barrier depends on energy level of fallout components, density and thickness of barrier. No material, regardless of density and thickness, completely blocks radiation



RADIATION SOURCES that must be considered are roof, ground and "skyshine". Don't overlook contribution from adjacent roofs and building setbacks. Note high PF areas in office building shown are within core on upper floors and basement. Structure studied has a steel-frame, concrete floor arches, masonry exterior walls, having 50% openings

THE SURVIVAL PLAN: What about physical protection?

As you set up a company organization for survival, a prime ingredient in the plan would be finding the best way to protect your people against the effects of nuclear explosion — primarily against radioactive fallout, but also as much as possible against blast and fire.

After an attack, fallout would threaten you from three directions (drawing, right, above). Some would accumulate on the ground around your plant, and some on rooftops. In addition, building walls would feel the radiation scattered by the air, sometimes called "skyshine".

Key to protection from fallout is to place a physical barrier between it and you—steel, concrete, earth, water, or wood. How well a material screens you depends on its density and thickness. To do an equal job of absorbing radiation, you would need thicknesses of 0.3-in. of lead, 0.7-in. of steel, 2.2-in. of concrete, 3.3-in. of earth, 4.8-in. of water, and 8.8-in. of wood. These figures represent a quantity called the *half-value layer thickness* or HVL.

The HVL figure shows in inches how much thickness of each material is necessary to stop half the gamma radiation outside from penetrating the barrier. Each HVL thickness you add to the first reduces what comes through another 50%. Two HVL thicknesses side by side let in only 25% of the total gamma radiation outside; adding a third HVL thickness lets in but 12½%, and so on. This is true as a general concept, results vary with specific conditions.

Use a material's HVL figure to approximate how effectively a barrier will soak up radiation energy. But the practical value of the barrier — its *protection factor*, or PF — depends on the location of the fallout in respect to the barrier and on the area of fallout.

A building's geometry plays an important role in protection against fallout, too. For example, protection factors would differ in two tall buildings of the same height and construction if one covers a larger area than the other, neglecting roof contribution. At the center of the first floor, the PF would be higher in the structure with the larger base simply because at that point you would be farther from the outside ground radiation. Likewise, the PF would differ at first floor center of two buildings with similar base areas and construction but varying heights. Neglecting ground contribution, the taller building would offer more protection because radiation would have farther to go from roof to first floor. Of course, in such calculations you must also consider the contribution from fallout on roofs of adjacent buildings.

What is a minimum acceptable protection factor? There is no standard figure, since it is impossible to predict the radiation level to which you might be exposed. One commonly suggested minimum is 100.

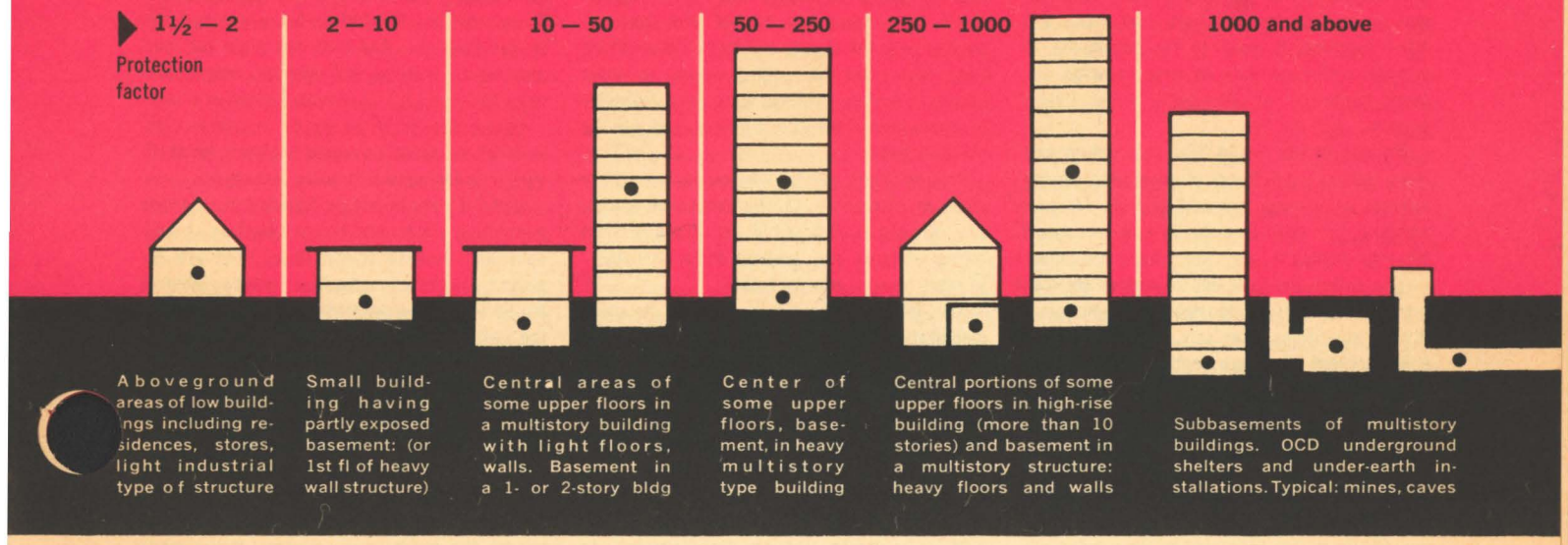
For many structures it may be practical to adopt the "core" shelter plan—in which you would set aside one area of a shelter offering highest possible protection, perhaps at the well-protected center. People would be crowded into this core, however uncomfortably, during the hours of peak fallout, then rotated between the core and shelter areas with lower protection factors. Or the rotating schedule might be used from the beginning of the shelter stay.

Spotting safe areas. A survey of your building should reveal areas that would offer some fallout protection without radical change. The choice would quickly narrow to areas with walls and ceilings of thick, high-density mate-

TYPICAL PLANTS, COMMERCIAL BUILDINGS AND UNDERGROUND SHELTERS

LIKELY SHELTER LOCATIONS in any building are those offering highest protection factors. Illustration below gives a general idea of the relative protection found in common structures. Use it as a guide only, to estimate protection against fallout. The PF values listed may be conservative, being based on isolated structures.

Your shelter survey starts with knowing construction detail of all your buildings, number of people normally on the property, placement of utilities. Roughly estimate total group the shelter can handle by allowing 15 sq ft of gross floor area per occupant. Gross area includes columns, some fixed equipment, storage for shelter supplies. Net area per person should be 10 sq ft. Shelter occupancy time may be limited by room volume rather than area, particularly in absence of mechanical ventilation. Natural ventilation from interior stairways, shafts, extends stay. Fresh air minimum: 3 cfm per person


1½ – 2
Protection factor
2 – 10
10 – 50
50 – 250
250 – 1000
1000 and above
Aboveground areas of low buildings including residences, stores, light industrial type of structure
Small building having partly exposed basement: (or 1st fl of heavy wall structure)
Central areas of some upper floors in a multistory building with light floors, walls. Basement in a 1- or 2-story bldg
Center of some upper floors, basement, in heavy multistory type building
Central portions of some upper floors in high-rise building (more than 10 stories) and basement in a multistory structure: heavy floors and walls
Subbasements of multistory buildings. OCD underground shelters and under-earth installations. Typical: mines, caves

rial and few windows and doors. Some degree of safety would be available, for example, in sub-basements, basements, centers of masonry buildings. You could thicken existing walls if necessary, and concrete baffles could be placed a few feet or so in front of windows and doors to screen out radiation while leaving them in service. To further guard, primarily against roof fallout, you could erect false ceilings using supported concrete planks.

For detailed help on how to survey structures for fallout protection, consult Office of Civil Defense publication NP-10-2, *Guide for Architects and Engineers.*

Shelters from scratch. If adequate shelter areas cannot be created in present buildings, you would probably construct new ones designed primarily as shelters. Such a structure could be engineered to withstand some blast and fire as well as fallout. It could take one of several forms; there are many designs for combination blast and fallout shelters. Some are all concrete; others use a multiplate corrugated-steel arch set on a concrete slab. Latter shelter could be built above ground, with an earth mound completely covering it; partly underground with an earth cover, or entirely underground. An underground shelter could be designed as the sub-basement for a building to rise on this foundation later. Whatever the choice, you should try to give the shelter some peacetime use—perhaps as a plant cafeteria or recreation center.

Typical group shelter suggested by the Atomic Energy Commission (in its booklet CEX-58.7) would accommodate 100 persons with a protection factor of 10,000 against fallout. This shelter would withstand blast pressure of 35 psi—which should make it safe against blast effects of a 10-mt weapon to within a few miles of ground zero. Tests have shown it could withstand a firestorm.

For any shelter, you must plan utility supplies. Water would be the first need; the best bet would be to store it in a closed system, unless you have a dependable well. Figure on a minimum of 2 quarts of water a day per person, another 2 quarts for washing. If you draw on public water supplies that might become contaminated or polluted, you should install filters for insoluble isotopes, ion-exchange for soluble ones, plus chemical treatment. You would also have to take account of buildup of radiation levels in ion exchanger and filters.

To provide ventilation, you could choose a variety of systems. For most fallout shelters, a simple mechanical ventilation system with filters to remove fallout particles should suffice.

A more elaborate system offers fully automatic, thermostatically controlled air conditioning for underground blast shelters. It draws 100% fresh air from outside, filters and conditions it to proper temperature and humidity, and removes used air. With an air conditioning system that removes carbon dioxide and adds oxygen, it would be possible to shut the shelter off from outside for 24 hours.

At the other extreme, in some situations you could use simple natural-draft ventilation.

Electric supply. You must also supply electric power to the shelter for lighting, ventilating equipment, some cooking, and possibly for sewage pumping. The answer would be an engine-driven generator and a stockpile of fuel. You should also install a separate electrical feeder from your main substation to shelter areas, so that you could use the normal power as long as it is available.

For sewage, you should include in the plans a collector tank with an ejector pump leading to a cesspool.

Decontamination facilities, for people who must come into the shelter after being exposed to fallout, should be installed near entrances. Recommended procedure includes removal and safe disposal of contaminated clothing, followed by a shower before donning fresh clothes.

The post-attack environment: What problems will it present?

In its day-by-day operations, your company depends on all sorts of links with the rest of the economy. It uses the services of the transportation, communications, utility, and banking systems. It relies—directly or indirectly—on outside sources for materials, fuel, food, and other supplies. It looks to the community to provide such essentials as water, sewage disposal, highways and other public works, health services, and the like.

Nuclear attack would tear that fabric and leave behind a patchwork of areas with varying degrees of damage (pages 2 and 3). For your planning, you need to visualize how this would hit your company—and what steps are under way to soften the blow and to restore services after an attack. It is impossible to predict post-attack conditions precisely, of course, and many present plans are tentative and subject to change. But here's a current summary of the probable situation in vital areas:

TRANSPORTATION — for moving food, fuel, medical supplies, material, and personnel — would be the service perhaps most essential to recovery. Railroads, with their fixed routes, are likely to be hardest hit. With adequate fuel supplies, trucks and other flexible forms of transport—such as aircraft—could operate by bypassing damaged areas.

Unfortunately, planning in trucking is confused by divided authority. One federal agency would have emergency control over carriers, another over the streets and highways on which they move. And this control seems to apply only to interstate carriers; there is no authority to coordinate intrastate truckers and private company fleets.

Present plans call for carriers to take these steps in emergency: (1) Warehouse all goods, sell perishables if possible. (2) Obtain permits —from at least one, perhaps three agencies— to start hauling priority traffic.

The industry has begun to form trucking mobilization groups that may become the core of a broad emergency transport system.

COMMUNICATIONS has several vulnerable points — among them the network of exposed lines and the lack of protection for radio and TV personnel and equipment. In addition, high-altitude explosion of large nuclear weapons could cause temporary radio blackouts.

Major common carriers are working to "harden" lines and equipment and to bypass likely target areas with self-contained underground communications channels. They also have repair crews, fully equipped and trained for disaster, spotted at widely dispersed points. Some radio and TV stations have launched protective measures. And there are plans for coordinating commercial and amateur radio operations to close gaps in coverage after an attack.

During the early period of recovery, communications facilities would probably be available only for highest priority messages.

UTILITIES are in danger because many power generating plants are concentrated geographically and because transmission lines are exposed. Suggested remedies include building multiple and interconnected lines, and dispersing switchyards. Many companies are studying ways to protect personnel and equipment, constructing alternate emergency control centers. Utilities have a major asset in personnel trained and experienced in dealing with disaster.

MONEY AND CREDIT is one area where plans are ready now. The Federal Reserve System has led other government agencies in preparing for the problems of recovery. It has made

THE RECOVERY PLAN: What needs to be included in it?

Planning for recovery from a nuclear attack takes an almost staggering effort of imagination. You must try to visualize the shattering of our complex civilization, the breaking of the many links that tie our economy together (above). If you are to plan at all, somehow you must picture the problems attack would create for your company and its people — and prepare now to cope with them.

Problems of the early post-attack period would be basically similar to the problems of survival. So they could be tackled best by the same organization—which would be in control not only during an attack but in the weeks after.

After the assault, trained workers should be able to foray briefly into plant areas that have been damaged, or contaminated by fallout. They should work in relays, to expose each team member to minimum radiation. The purposes of such trips should be ranked by priority spelled out in your company's plan; at first, the goal should be only to take steps that would make shelter life safer.

Decontamination would be a major problem, particularly on roofs and on land surfaces around the plant. An automatic flushing system, draining to a safe distance, might help clean roofs; as mentioned earlier, a shielded bulldozer could scrape contaminated soil away from facilities. These chores must be under radiological controls.

A related job — subject to the same careful controls — would be removing debris from possible fire and blast damage and making repairs. Here again, priority should go to steps that would yield the most immediate benefit.

You must assume that you would perforce be self-sufficient for some time after an attack. But you would try to link up as soon as possible with any interrupted utilities. You should be equipped to test your water supply for radioactivity and potability until notified that it is safe.

Information needed. You should plan early efforts to contact others in the community—the civil-defense organization, disaster-relief groups, neighboring plants that might offer—or need—mutual aid. In this immediate post-attack stage, there would be a desperate need for information. Employees would want to know what happened to their families, their homes, the community; you would need to know about local supplies of food, fuel, and other supplies, about casualties, about regulations to keep law and order.

In some nations with extensive civil-defense plans — Sweden, for one — martial law takes effect as soon as an attack warning sounds. U.S. plans thus far made public do not call for martial law—although it would seem possible. Instead, the approach has been to try to insure that local and state governments would continue to function. Federal agencies have already done a great deal toward specifying automatic lines of succession for officials, setting up alternate headquarters or hardening present sites, preserving essential records. All but five states have taken some legis-

lines of succession and authority clear. Member banks have been encouraged to store duplicate records in safe locations from which they could operate if necessary. More than two years' supply of Federal Reserve notes has been placed at strategic points around the U.S. The Fed itself has an emergency headquarters.

A check with the Fed and its member banks may greatly simplify your own plans for meeting emergency needs for money and credit.

AGRICULTURE: Food is not likely to be a critical problem early in the recovery, except for local shortages caused by transportation snarls. The grim probability: more food would survive than people.

Fallout does not harm food in cans or in non-porous bags and packages that remain closed. So most stored food would be usable, except in heavily damaged areas. Some of the standing crops that survive could be harvested and used after decontamination. Livestock killed by radiation would be edible if promptly dressed and refrigerated.

Food from current inventories and stockpiles would probably be sufficient to support the survivors while they slowly returned some fallout-contaminated farmland to cultivation.

PUBLIC WORKS would present a variety of problems. According to most experts, water supply would not be a serious worry. Surface waters and open reservoirs would be contaminated by fallout, but most of this could be filtered out. Some fallout would be soluble, however, and this might require either waiting for radioactivity to decay enough for safe use, or installation of ion-exchange treatment in addition to usual treatment for potability.

Water distribution systems, sewers, and streets would suffer various degrees of damage. Removing debris would be a huge chore in areas damaged by fire and blast. OCD has briefed state and city public works agencies on their responsibilities in these jobs. Emergency equipment—including generators, pumps, water purifiers, and pipe—are already on hand at 24 spots around the country. To encourage states and cities to buy similar supplies, the federal government will put up matching funds to equip and train local personnel.

Any company registering equipment, personnel, and engineering talent with a central disaster-relief organization can obtain "Plan Bulldozer" from Associated General Contractors. The plan includes instructions for a cooperative program to clear debris quickly.

HEALTH SERVICES will present one of the gravest post-attack problems. Even with effective shelters, an attack would leave many people injured and sick. Physicians, nurses, hospitals would be lost—most heavily in the areas with most casualties. And in the aftermath of attack would come infections and disease.

The U.S. Dept. of Health, Education & Welfare has designed a basic package unit for an austere but effective 200-bed general hospital. Some 1900 of these units have been bought and placed in critical areas away from likely targets. Plans are under way to distribute another 750 units and to equip all of them with 30-day supplies of medical equipment and supplies. HEW is also responsible for stockpiling plasma, serums, essential drugs, supplies.

To offset a shortage of doctors and nurses at least partly, HEW is readying a program called "Medical Self-Help." This provides basic training in first aid and general medical treatment. The course will be given to civil defense groups and industrial disaster organizations.

lative steps along similar lines, although only a few have scored much progress.

Despite these steps, law and order could break down in some areas. So your company's plan should provide for handling such problems both inside and outside your plant. On the outside, your organization could help restore order in the community. This requires close integration of your group and local civil government.

Long-term plan. For the long-range recovery of your company, you face planning problems different from those of survival during and immediately after the attack. Logically, then, you should assign such planning to a separate group, usually drawn from top management. This committee's primary worry would be outlining steps to take, in advance, to preserve the company's organizational framework and the assets — tangible and intangible — on which it depends.

The bylaws of most companies tightly limit the board of directors—where it may meet, what constitutes a quorum, how new directors are elected, and so on. Such restrictions might make it legally impossible for the company to carry on if a massive disaster should incapacitate many directors, or resulting transportation snarls should prevent a quorum.

To correct this, your plan should include bylaw changes to permit surviving directors—or even a single director—to fill vacancies without delay, pending a regular or special stockholders' meeting. You might also create an emergency management committee, empowered to act for the board of directors under specified conditions. Any such steps should be based on careful legal study. Some states have modified their laws to give you more flexibility — or plan to do so — but others have not. A good starting point for your program: the literature on corporate continuity published by the Office of Civil Defense, industry and trade associations, and other such groups.

As a next step, you should review all company functions in the light of probable conditions during the recovery. From this review, you would be able to pick the most essential jobs and allot them among the company's staff — with successors named for each post. This succession, too, may require bylaw changes.

For recovery, a company would need essential records to continue operating. Storing them safely would be the smallest problem; much more difficult is deciding which records are truly vital. Some executives recommend dividing them ruthlessly into three categories:

- *Vital records*—irreplaceable; of less value in reproduced form; necessary to recover monies promptly or to restore production, sales, and service.
- *Important records* — very expensive to reproduce, in dollars or time.
- *Useful records*—whose loss would be inconvenient, but could be replaced readily.

Records such as the following would probably qualify for safekeeping: property deeds and other proofs of ownership of assets; stockholder data; insurance certificates;

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FEDERAL AGENCIES AND CIVIL DEFENSE

By executive order (August 1, 1961), the President transferred basic responsibility for civil defense from the former Office of Civil Defense and Mobilization to the Department of Defense. With its remaining functions, OCDM was renamed Office of Emergency Planning.

Specifically, the Secretary of Defense is in charge of development and execution of a program to minimize the effects of attack, including informing and educating industry and the public in methods of survival. This includes a fallout shelter program, a warning and communications system, and a program to assist state and local governments in such post-attack community services as health and sanitation, maintenance of law and order, firefighting and control, debris clearance, traffic control, provision of water supplies.

The Director of the Office of Emergency Planning is responsible for planning continuity of state and local goverments, the natural-disaster relief program, the defense mobilization program, the strategic and critical materials stockpiling program.

Previously established policy calls for making maximum use of existing Federal departments. Typical civil-defense responsibilities that are assigned to other agencies include:

Dept of Agriculture: Food stockpiling, rural fire control, protection of vegetation and animals against radiological, chemical and biological hazards.

Dept. of Commerce: Restoring streets and highways; use of emergency shipping.

Federal Aviation Agency: Emergency use of civil air transport, civil airports and airways.

Dept of Health, Education, and Welfare: Medical stockpiling; care of refugees from attack, including location services.

Dept. of Interior: Emergency plans for power and petroleum.

Dept of Labor: Planning use of emergency manpower, except medical, in immediate post-attack period.

Post Office Dept: Registration of individuals and families.

Housing and Home Finance Agency: Emergency housing and community services in the post-attack period.

Interstate Commerce Commission: Plans for use of domestic service transportation in emergency.

patents, important engineering drawings and process data; records of employee pension funds and other such financial plans; important contracts, including union contracts. These would also have to be kept up to date, of course.

If you carry on business at several widely separated points, you should store duplicates of vital records at each location. You should also arrange for management personnel at each point to take control of company operations at other locations, if necessary. Plans should also be made for mutual aid between the several plants and offices.

In some cases, you should consider establishing alternate headquarters, with duplicate records and living quarters. This could give a one-plant company the advantages of a larger company with dispersed operations.

If an attack struck when employees were not at work, they would need to know where to report when conditions permitted. One answer would be to designate emergency centers, possibly in suburban homes of supervisors.

Fiscal plans. Your plan should set up emergency financial procedures. For example, you would probably need a simplified accounting system for use after attack. You would want funds quickly available for wage payments, advances to employees, and buying food and supplies. One solution might be to preprint checks of fixed denominations and distinctive design. They would be stored in a safe place and used only in emergency, with the signature of anyone of a list of management personnel.

Finally, you must try to prepare for restoring production in an emergency economy — probably with wage and price controls, government allocation of materials and manpower, and so on. Production would quite likely be geared to goods most useful for recovery.

You would want to analyze how your company would be suited to alternate lines of production, perhaps develop alternate sources of supply, and production techniques to make your operations as flexible as possible.

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THE TASK AHEAD

If our nation should suffer a large-scale nuclear attack, the measure of our ability to survive and recover will be the courage with which we appraise the dangers, and the vigor with which we act to prepare for them.

In such planning, business and industrial executives have a special stake and exceptional responsibilities. The organizations they direct not only provide the sinews of the economy on which recovery would depend, but can — and should — provide focal points of direction and leadership.

Some companies have already displayed commendable foresight and enterprise in preparing for the possibility — however unlikely — of nuclear war. But a big job remains to be done. I urge every responsible American executive to give these problems his immediate and earnest attention.

Robert S. McNamara
Secretary of Defense